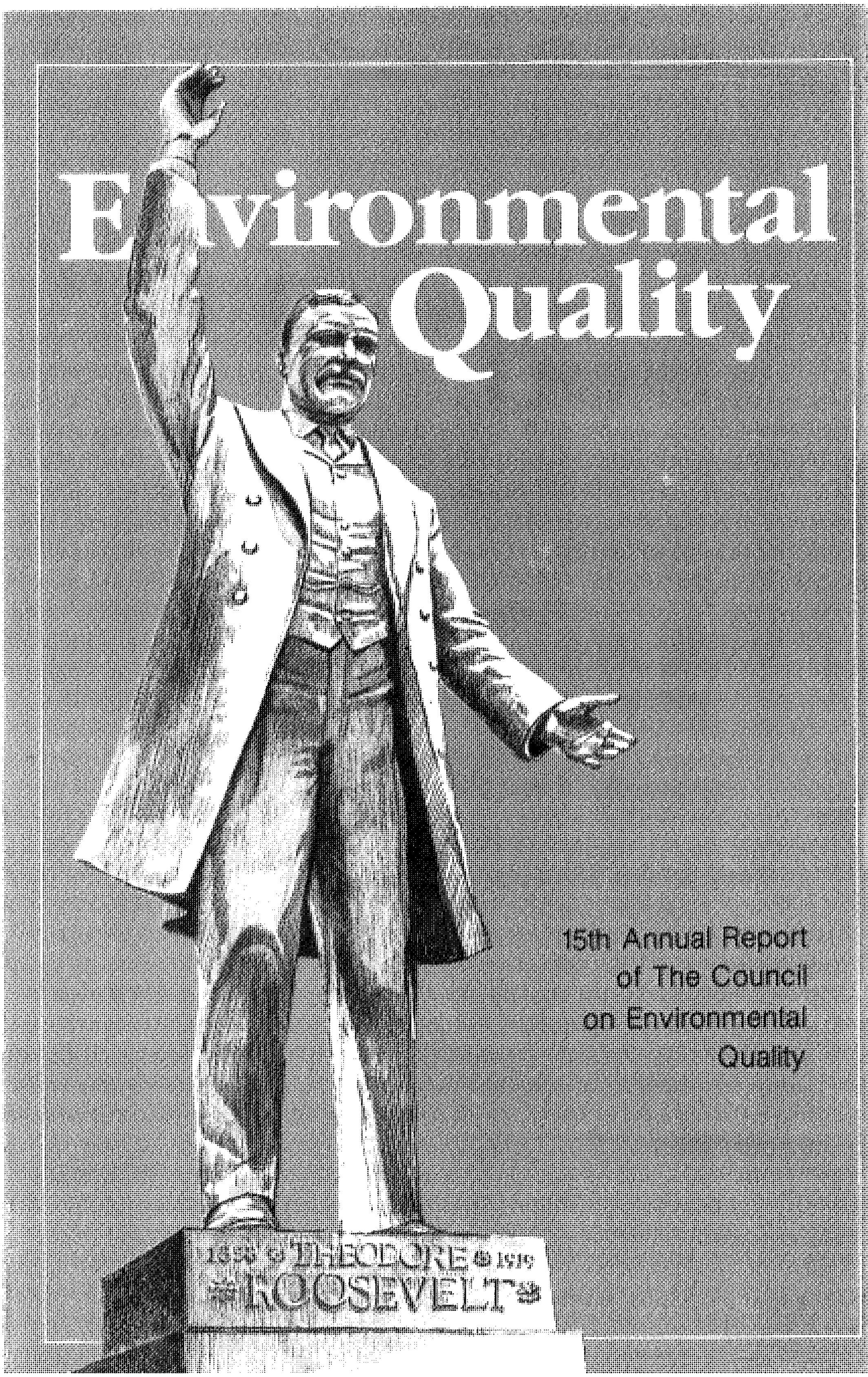

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". . . President Roosevelt reached the American conscience, and conservation and environmental protection became an inseparable part of the American creed. He told us, 'The Nation behaves well if it treats the natural resources as assets which it must turn over to the next generation increased, and not impaired, in value.'

"Those words must remain an inspiration to all of us: an obligation to everyone charged with the stewardship of our resources . . . .

". . . If we have learned any lessons during the past few decades, perhaps the most important is that preservation of our environment is not a partisan challenge — it's common sense. Our physical health, our social happiness, and our economic well-being will be sustained only by all of us working in partnership as thoughtful and effective stewards of our natural resources.

"We must and will be sensitive to the delicate balance of our ecosystems, the preservation of endangered species, and the protection of our wilderness lands. We must and will be aware of the need for conservation, conscious of the irreversible harm we can do to our natural heritage, and determined to avoid the waste of our resources and the destruction of the ecological systems on which these precious resources are based. We must and will be responsible to future generations.

"But, at the same time, let us remember that quality of life means more than protection and preservation. As Teddy Roosevelt put it, 'Conservation means development as much as it does protection.' Quality of life also means a good job, a decent place to live, accommodation for a growing population, and the continued economic and technological development essential to our standard of living which is the envy of the whole world.

"We can best serve the interests of the American people, and generations yet to come, by seeking to harmonize competing and to reconcile legitimate social goals. And in doing these things, we will be a trusted friend to both the environment and the people . . . ."

REMARKS BY PRESIDENT RONALD REAGAN

Theodore Roosevelt Island
July 11, 1984

Environmental Quality

The Fifteenth
Annual Report of the Council
on Environmental Quality
together with
The President's Message
to Congress

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402

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The President's Message

To the Congress of the United States:

I am pleased to transmit to the Congress the 15th Annual Report of the Council on Environmental Quality.

By most conventional measures of environmental quality, the air and the waters of the United States continue to improve as a result of the enormous national commitment to these goals that has come about since 1970. Likewise, we continue to be ever more careful stewards of our lands and their abundant natural resources — wildlife, soils, minerals, fuels, forests. We are moving aggressively to eliminate serious contamination of valuable land and ground water from the past mismanagement of hazardous wastes, and I have urged the Congress to reauthorize the Federal "superfund" program so that our momentum in this important work is not lost.

As the largest sources of environmental pollution have been controlled, and critical lands protected, our attention is drawn to highly specialized problems — such as detecting and determining the significance of trace levels of chemical substances in the air, in surface and ground waters, in fish tissue, and in soils. Further progress in eliminating environmental pollutants wherever they are found to have significant impacts is leading to the control of larger numbers of smaller, more dispersed sources of potential environmental contamination, including small firms, farmers, and individuals. This trend has enormous implications, both in terms of the costs of removing such small amounts of pollution from such large volumes of the medium in which it is found, and because it seems to require detailed regulatory interventions into individual lives. Recognizing this, the Council on Environmental Quality's report documents and suggests a broader range of environmental policy alternatives that ought to be considered.

The policy recommendations contained herein are based on two fundamental propositions. The first is that the spirit, creativity and personal drive of individual Americans will always be this Nation's greatest resource. It is the human genius that turns physical substances into resources, and human creativity in a free society is never exhaustible. Second, human institutions can encourage or constrain the ability of people to make the best use of their resources and to solve

environmental problems. Rational policies that recognize and make effective use of economic incentives should help to improve the management of our environment and natural resources by stimulating new achievements on the part of the American people. Efficient use of the Nation's resources, guided whenever possible by free markets rather than centralized controls, will work to promote environmental health, economic productivity, and fiscal responsibility.

Some of the specific policies that follow from these perceptions are discussed in this report. They include enlisting volunteer efforts, long characteristic of this Nation, on behalf of parks, wildlife, and natural and historic preservation.

The Federal government's own activities should avoid adversely affecting environmental quality. This is now accomplished chiefly through the environmental impact assessment process. Another means to implement such a policy is contained in the Coastal Barrier Resources Act, which removed Federal subsidies for the development of these sensitive lands. Studies are currently underway to assess its effectiveness and to consider its applicability to other areas of critical environmental concern.

Efforts to create markets and to consider market-like management practices, that are being tried by Federal agencies in air quality and some land and water resource management programs, can be extended into other areas. A variety of successful State, local, and private market-oriented initiatives that have solved pressing water resources problems without Federal funds is documented in this report. And on the public lands, proposed user fee revenues would be invested in maintaining facilities that personally benefit recreationists and others, so that only the real public benefits would be paid by the taxpayer.

Finally, environmental protection regulations should be fashioned so that innovation and the substitution of progressively safer new products and technologies for old ones are not inhibited, especially where risk reduction or increased benefits will be the likely result. We must be alert lest government restrictions, however benevolently aimed at protecting the public as a whole, begin to hamper the creativity and productivity of entrepreneurs and other individuals who also can bring about social advances.

This Administration is dedicated to promoting conservation and stewardship. Conservation means the efficient use of natural resources. Stewardship entails a love of the land and a determination to pass onto future generations a high quality environment suitable for human living. A strong Nation is one that is loved by its people and, as Edmund Burke put it, for a country to be loved it ought to be lovely. The ideas of conservation and stewardship suggest also that economic productivity is not a proper end in itself, but is only a means to the end of improved lives for all Americans. Riches alone do not guarantee the maintenance of a social order in which people can take pride.

But conservation and stewardship should never come to mean opposition to change through the fear that new development will more likely bring personal decline than social advance. The discomforts of change will be more than compensated by the benefits of a dynamic economy, in securing opportunity for new generations and in rewarding individual enterprise and initiative. A society of rising accomplishment and enhanced expectations will provide a better life for its people: a cleaner environment, and improved health and nutrition, superior educational, cultural, and recreational opportunities.

Inspired by promise, sustained by hope, past generations of Americans built a free and prosperous Nation based upon the principles of individual initiative and personal responsibility and upon private institutions of many types. They worked to turn our abundant natural resources to productive use and they learned to love their new land with its grand vistas, its mountains and forests, its fertile fields, and its bustling cities. Environment and natural resources policy can be used to help further these ideals so that liberty, prosperity, and a beautiful and healthful natural environment will continue to bless the lives of the American people. Then surely our good times will not have passed; indeed, our best days will be yet to come.

Ronald Reagan

THE WHITE HOUSE

EXECUTIVE OFFICE OF THE PRESIDENT
COUNCIL ON ENVIRONMENTAL QUALITY
722 JACKSON PLACE, N.W.
WASHINGTON, D. C. 20006

LETTER OF TRANSMITTAL

THE PRESIDENT:

Sir: The Council on Environmental Quality herewith submits its fifteenth Annual Environmental Quality Report in accordance with Section 201 of the National Environmental Policy Act of 1969 (42 U.S.C. 4341).

Respectfully,

A. Alan Hill
Chairman

William L. Mills
Member

Jacqueline E. Schafer
Member

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CONTENTS

APPENDICES

TABLES

FIGURES

Prologue: Reflections on Environmental Policy

This report is the 15th Annual Report of the Council on Environmental Quality (CEQ) and marks another milestone in the development of a unified national environmental policy. That development has not been easy. For the past 15 years, numerous statutes dealing with environmental quality and natural resources have been enacted, with each new law designed to solve some specific pollution or resource problem, rather than to advance environmental quality as a whole. Thus, they provided little flexibility for resolving difficulties arising when the "solution" to one problem caused or exacerbated another. The task of blending these diverse laws into a more unified environmental policy, and of structuring the responsibilities of the environmental agencies accordingly, is a difficult one. This report may be viewed as a progress report in that effort.

The mandate for this annual report is contained in Section 201 of the National Environmental Policy Act of 1969 (NEPA), which describes in detail the broad scope of this report:

> "The President shall transmit to the Congress . . . an Environmental Quality Report . . . which shall set forth
>
> 1. The status and condition of the major natural, manmade, or altered environmental classes of the Nation, including, but not limited to, the air, the aquatic, including marine, estuarine, and fresh water, and the terrestrial environment, including, but not limited to, the forest, dryland, wetland, range, urban, suburban, and rural environment;
> 2. Current and forseeable trends in the quality, management and utilization of such environments and the effects of those trends on the social, economic, and other requirements of the Nation;
> 3. The adequacy of available natural resources for fulfilling human and economic requirements of the Nation in the light of expected population pressures;
> 4. A review of the programs and activities (including regulatory activities of the Federal Government, the State and local governments, and nongovernmental entities or individuals with particular reference to their effect on the environment and on the conservation, development and utilization of natural resources; and
> 5. A program for remedying the deficiencies of existing programs, activities, together with recommendations for legislation."

Given the magnitude of this charge, it has been necessary to select certain topics for attention, while neglecting others. The scope of environmental and resource conservation activities is far too vast to permit any encyclopedic treatment. Thus, this report reflects, as did its predecessors, an uneasy compromise between the breadth and depth of the coverage.

This report reviews each of the substantive areas of environmental policy (Part I) and natural resource policy (Part II). Each of these sections continues a past CEQ practice of including a special commissioned paper on a topic not

addressed in earlier reports, which represents an innovative approach to protecting the environment or conserving natural resources. Part III reviews the activities led by or directly involving CEQ during the past year.

This introduction summarizes the major divisions of this report (each chapter includes its own introduction), identifies the themes that recur in these chapters, and presents several suggestions to remedy the "deficiencies in existing programs and activities."

ORGANIZATION AND OVERVIEW

The language mandating this report requires a review of the nation's environmental and natural resource activities. This charge includes all aspects of environmental quality including the air, land, and waters and the resources — economic and noneconomic — found therein. The report deals with this complexity by dividing the discussion into three major sections. Part I deals with pollution control and environmental protection and describes the efforts to address the initial responsibilities of the Environmental Protection Agency (EPA) — the control of air and water pollution — and the more recent responsibilities of dealing with hazardous materials. Part II addresses land uses and reviews the activities of the various federal "landlord" agencies, such as the Bureau of Land Management and National Park Service within the Department of the Interior and the U.S. Forest Service within the U.S. Department of Agriculture. This section also discusses natural resource questions, and the current status and availability of water, energy, mineral and nonmineral resources.

Both Parts I and II contain a special report that explores in somewhat greater detail an important topic or approach that has received less attention in earlier reports. The special report in Part I (Chapter 4, "Risk Assessment and Risk Management") describes an effort within EPA to clarify the handling of risk questions. That report notes that efforts to control risks may themselves create risks; and that, therefore, we must consider how best to advance human and environmental health, rather than only how to reduce the risks from any one specific substance or process. The special report of Part II (Chapter 9, "The Public Benefits of Private Conservation") develops further a theme first introduced in the 1983 CEQ report — that private groups and individuals now play an important role, and might play an even more important role, in advancing environmental and natural resource objectives.

Part III of the report describes activities of the Council itself over the last year, and provides a current review of selected environmental science projects. The remainder of the report discusses a number of international environmental programs, and summarizes recent developments under NEPA, including a special report on referrals under CEQ's NEPA procedures. The Appendix includes updated statistical tables dealing with environmental quality and natural resources.

Part I: Pollution Control and Environmental Protection. EPA's authority has gradually expanded to cover one after another of the media that pollutants might contaminate, the stages of materials processing, the types of products and processes allowed, and, finally, the ways these products are distributed and used in our economy. Emphasis has shifted over the last decade from the

relatively simple task of controlling the major "bulk" air and water pollutants to that of controlling trace hazardous substances. The easiest problems are well on their way to being solved. The remaining problems are twofold: how do we control the environmental problems resulting from the dispersed, cumulative actions of large numbers of individuals and smaller firms; and, two, how do we manage the risks associated with the introduction or limitation of new substances into the economy.

These problems are compounded by the lack of any overall "organic act" defining or reconciling the various environmental laws. Each law is designed to address some specific subset of environmental concern. Often these laws have been drafted with an imperfect understanding of how they interrelate with other environmental and nonenvironmental laws. Often, too, their assignments of authority have led to management conflicts between federal agencies or between federal and state authorities.

Much of this environmental legislation has emphasized pollution control. To induce and accelerate compliance by public and private groups with these regulations, the laws provided for both direct and indirect subsidies. These programs have demonstrated their success in stemming air and water deterioration, as discussed in the status and trends sections of Chapters 1 and 2. However, this success has primarily been due to the control of large "point" sources, and has been very costly. Further progress will require similar success in controlling smaller, more dispersed waste sources. Such a "holistic" environmental policy is now required; whether the current regulatory structure can actually manage a task of this complexity remains unclear.

The size of this report indicates the enormity of the task assigned the nation's environmental agencies. It is difficult to evaluate the success of that effort. We do know that in most regions of the nation and for most pollutants for which data exist, environmental laws certainly contributed to this success. However, these achievements were costly, and have increasingly required that controls be extended into areas of individual choice. The costs of these programs, together with the tensions arising from detailed regulatory interventions into individual lives, have stimulated EPA and others to consider a broader range of policy alternatives. Some of these alternatives are discussed in this report.

One point that is raised throughout this section (see also Parts II and III) is the uneven quality of almost all environmental data and the absence of widely accepted indicators of changes in ambient conditions. The most useful data sets are those that describe air quality. Surface water quality data are copious, but less well-organized, while data on ground water are available only for a tiny fraction of the aquifers in the nation. The far more complex monitoring problems posed in seeking to understand the presence and flows of trace hazardous materials in the environment have scarcely begun. Given the complexity and probable costs of these monitoring tasks, it is essential to find strategies that economize on the acquisition of extensive and accurate data, yet are sufficient to allow improvements or degradation in environmental quality to be readily detected.

Part I also deals with EPA's efforts to control the possible harms associated with the use and disposal of hazardous materials. EPA is now responsible for managing the risks associated with the introduction (or new use) and eventual discard of such materials. Among the problems that have arisen from these

new responsibilities is the "new source bias" problem, that is, the possibility that regulatory practice might be biased against newer and possibly safer products in favor of the status quo. Many have come to believe that EPA and other risk management agencies may favor severe approval procedures, even if the effect of these procedures is to slow down the rate at which newer and safer products come on the market.

This bias problem will not be easy to eliminate. Bureaucracies, like all institutions, respond to incentives. The errors that are most likely to be blamed on the agency are those associated with approving a process, product or use that results in unfortunate consequences. In contrast, the costs of falsely rejecting or delaying a safe product are not normally attributed to the agency, since they are prospective and not readily estimated. The result is that bureaucracies act "conservatively" in the sense of imposing requirements for approval that minimize both the costs and risks of nonaction. Paradoxically, our efforts to reduce risk may make our society more dangerous, since progress in the safety area as elsewhere requires that we replace products and technologies that are reasonably safe with those that are safer.

Such risk management difficulties have long been recognized in other regulatory areas, and have yet to be resolved. Within EPA, the recognition of the bias problem, among others, has led to efforts to systematize a formal risk assessment/risk management policy. The objective has been to separate all scientific aspects of a regulatory policy question from those involving judgment. The hope is that good science in the risk assessment phase and improved program integration in the risk management phase will substantially improve EPA's decision process, and the public's understanding of its activities. Unfortunately, many objections are raised even in such scientific areas as dosage rates, the weight to be given positive and negative animal tests, and the appropriate techniques for extrapolating such results to man. Whether formalization of the existing approach will resolve the inherent problems associated with developing policy in the area of human safety is unclear. It is all too likely that this policy formulation process will remain highly controversial. But it can also be expected to help the agency set priorities, manage more efficiently, and make more consistent and explicit decisions leading to the reduction of risks and the advancement of human and environmental health.

Part II: Land and Natural Resources. The federal government is the nation's largest property manager. The Bureau of Land Management (BLM) and the Forest Service manage most of this acreage; however, almost all public agencies control some properties. These lands contain considerable mineral, timber and nonmineral resources. Federal holdings have recently increased as a result of the decision of the U.S. to formalize its control over the 200-mile strip around our shore lines (the Exclusive Economic Zone, a region that includes the Outer Continental Shelf).

The federal property management role is far older than the government's involvement with pollution questions, and in many ways the problems faced are less complex. Unlike the management of pollution questions, the management of federally owned resources raises problems similar to those addressed in the private sector. Thus, the federal government has the example (good and bad) of private management to guide it in developing its own property

management strategies. Indeed, much of the nation's timber, pasture, mineral and nonmineral resources is privately owned and managed.

Over the past 15 years, a fierce debate has arisen over the adequacy of natural resources, with one group arguing that the U.S. (and perhaps the world) had reached the "limits of growth," and that we were "running out" of many essential materials. Energy resources, especially petroleum and natural gas, were often singled out for such warnings. Typically, adherents to this view called for a more managed economy, for an explicit recognition that humankind was crowded aboard Spaceship Earth. Indeed, they seemed to be calling for the appointment of a Captain for our planet. These pessimistic views were countered by those of another group, sometimes referred to as the "cornucopians." This group argued that past scarcities have been swiftly overcome by mankind's ability to innovate and substitute and that this progress can be expected to continue. The cornucopians suggested that the U.S. was not faced with any natural resource crisis and, therefore, saw no need to adopt any emergency governmental responses.

Based on recent data, it appears that, at least in areas where the market is allowed to operate, the optimists are correct. Oil price deregulation and a return to market allocation procedures seems to have stimulated both energy conservation and production. The result has been an increase in the availability of domestic energy in the U.S. These developments have also begun to redirect the attentions of both schools of resource management away from questions of physical availability toward the more central question of the incentives and institutional arrangements developed to manage these resources. The success of resource-poor, but incentive-rich, nations in the third world has also done much to indicate that scarcity arises less from nature than from society's institutions.

There has similarly been a trend to consider more market-oriented management practices within the U.S. government. In the areas of natural resource and land management, the resources involved are akin to those managed privately. As a result, government agencies have long considered the possibility of adopting market and market-like solutions to fulfilling their management responsibilities. Over the years, there has been considerable experimentation with establishing fees (water and grazing fees are discussed in this report), auctioning usage rights (for example, oil leases), and clarifying "property rights" to broaden their applicability and value (allowing transferable water rights and grazing fees, for example).

Caution, however, is advised in seeing market solutions as an "easy" way of improving environmental quality. Reliance on market approaches to natural resource management has not eliminated political controversy. Indeed, some of the major political problems encountered in the environment and natural resource areas have involved disagreements over the wisdom and nature of such procedures. Government agencies have been charged with "giving away" the nation's resources, in recent energy auctions. The government is charged with getting the "best buy" for the nation and any mistakes are likely to lead to political charges of mismanagement and favoritism.

One of the more encouraging discussions in this regard is contained in the Chapter 9 special report on "The Public Benefits of Private Conservation." That chapter reviews a range of nongovernmental activities that have resulted

in the conservation and enhancement of environmental amenities. The range and creativity of approaches revealed in these illustrations suggest that non-governmental entities might play a much more important role in these areas than has been heretofore recognized. Steps whereby these groups might be encouraged are also discussed.

Part III: Current CEQ Activities in Environmental Policy. The National Environmental Policy Act gives CEQ a broad mandate to gather information, analyze environmental conditions and trends, conduct studies, appraise programs and activities of the federal agencies, and to develop and recommend national policies that foster environmental improvement. In the early years following enactment of NEPA, most of the attention of the Congress and Executive agencies centered on the enactment of legislation, and the institution building that was needed to implement federal regulations and pollution abatement and resource management programs. Yet during that time few broadly accepted environmental indicators were developed which permit a consistent and easily usable assessment of ambient conditions, the sources and processes of changes in conditions, or of the effectiveness of those government programs. The most often cited exception is the pollutant standard index of urban air quality.

An enormous quantity of environmental data is collected every year, at great cost to local, state and federal agencies as well as the regulated community, but the systems which guide the collection of such information are *ad hoc*. Consequently, the data sets are of widely varying degrees of usefulness. One of the Council's principal objectives for the immediate future is to evaluate and facilitate the improvement of these monitoring systems among federal agencies, and such a project is discussed fully in this section of the report. It is also a priority identified in a Council-sponsored survey of corporate users of government environmental and natural resource information, and in a Council-sponsored review of long-term environmental research and development efforts.

THEMES AND RECOMMENDATIONS

A number of themes emerge from this report. One that permeates many discussions is the extent to which the current regulatory control over environmental quality and natural resources has moved our nation strongly in the direction of a "planned" economy, or at least one where most economic activity requires prior governmental approval. The scope of the tasks defined under current environmental and natural resource policies is massive: the federal government is charged with managing the whole economy as it impacts upon environmental or natural resource questions, which increasingly means almost every activity by almost everyone in society. In principle, all "border crossings" between man and the environment are now guarded. Almost everything that was once "neglected" has been dealt with in one or more environmental statutes. Without conscious choice, we have selected a fairly centralized, command-and-control procedure to govern all environmentally relevant aspects of our economy. Since, however, almost every human activity in some way affects the quality of the environment, this entails an unprecedented adoption of regulatory control over the whole economy.

A second theme — in part, a reaction to the managed economy approach

— has been an increased awareness of the market as an alternative means of reconciling conflicting values, while preserving resource and environmental amenities. There has been a growing realization that environmental problems largely arise because of the prevalence of "common property" resources. Unowned resources are more likely to be over-exploited than resources privately owned and managed, since a private owner directly benefits from the preservation and maintenance of such resources and thus is more likely to act as a responsible steward. Examples of the efficacy of ownership as a resource/environmental protection tool have begun to be more widely discussed, particularly in such areas as ground water.

Obviously, there are massive problems with translating this observation into a general tool of environmental management. However, this report begins to explore that potential and to review the steps required, if such an approach is ever to be implemented. Private property approaches have been viewed with caution by many individuals who advocate environmental values. The view has often been expressed that self interest is incompatible with environmental and resource conservation values — and that private approaches are limited to for-profit groups and are therefore unreliable. A special report (Chapter 9) begins to cast doubt on this holding. First, the report illustrates where private for-profit firms have taken actions in conjunction with profit-maximizing activities that have advanced environmental values, including the acquisition of buffer zones around industrial or energy facilities. These zones, which are created to reduce liability risks to the firm, often preserve significant environmental and wildlife habitats. This special report also discusses the important yet often overlooked role of the private nonprofit organizations. That discussion increases confidence in entrusting management responsibility for a select range of "small commons" to groups with a demonstrated capability to protect environmental values — and the credibility needed to gain that chance.

In the pollution control area, there has also been some movement toward market-like regulatory approaches. The intellectual basis for such reforms is the growing criticism of centralized command-and-control approaches. That rethinking, however, has not yet led to any widespread acceptance of market alternatives. The most successful of these market approaches to date has been the "bubble" concept developed in the air pollution areas. Under the "bubble" concept, a firm wishing to build or expand can "purchase" cleanup from other firms and thus "offset" the additional pollution that expansion will entail. "Bubbles" represent a limited property rights approach to pollution control and present a less costly alternative and possibly a more effective control strategy.

This idea was introduced over a decade ago and has very gradually been developed and implemented. The slow progress of this relatively mild innovation indicates just how difficult it is to modify existing environmental control policies. Efforts to extend the "bubble" concept to a broader range of conditions continue, however. There may be less difficulty in applying the property rights approach in other areas of pollution control. One possible role might be to address the identification problem that now creates much discord in addressing some issues, such as acid rain in which the potential sources of the acidity are distant from the sites where harm is incurred. A property-rights perspective would consider ways to "brand" the emissions of the largest firms

viewed as potential contributors to the acid rain problem. Branding has long been used to solve the identification problem for fugitive resources (whose cow is eating my grass, for example) and might well have broader applicability.

The report, therefore, describes an active search for ways to address environmental quality and resource conservation problems in new and innovative ways. Clearly, these efforts are important. However, it is also important to note that this Administration along with the vast majority of all Americans continues to support the environmental agenda. Possibly no other national goal retains such strong public support from such a broad base of the population. In a very real sense, all Americans are now environmentalists. The disagreements that have arisen and are likely to continue to arise concern the selection of the policies viewed as best able to advance environmental objectives. All answers are not yet available. This report is but one effort to ask the right questions.

PART I: POLLUTION CONTROL AND ENVIRONMENTAL PROTECTION

Chapter 1
Air Quality

National efforts to improve air quality continue to show positive results. Evidence from a variety of indicators — at the national, regional, and local levels — points to the conclusion that the nation's air quality is improving. Federal standards have been achieved for four of the six criteria air pollutants in most areas of the country. The two criteria air pollutants that persist as problems are carbon monoxide, which is a marginal problem except for a few metropolitan areas, and ozone, which is a more pervasive problem; however, a downward trend is evident for both of these pollutants.

Since a major source of both ozone and carbon monoxide pollution is motor vehicle emissions, federal control programs to reduce such emissions have contributed significantly to their decline. Stringent emission standards for new production vehicles, cars equipped with emission-control devices, leaded gasoline phase-down programs — all are having a significant effect.

This progress, however, was not the result of a breakthrough; rather, it was made incrementally with the introduction over time of successive generations of technological improvements.

In the area of hazardous air pollutants, greater difficulties exist both in assessing the extent of the nation's air toxics problem and in identifying the dominant contributory sources. To try to assess the scope of the hazardous air pollutant problem, the Environmental Protection Agency completed a comprehensive study in 1984. This assessment, while not proposed as the basis for new laws, is intended to orient policy-makers to the magnitude and nature of the toxic air pollutants problem and to stimulate discussion of alternative strategies for a more comprehensive approach to air toxics control. This type of approach — broadscale in nature — that assesses the risks involved and then devises strategies to manage those risks, holds promise of dealing not only with the air quality issues, but also with other areas of environmental concern.

Conditions and Trends

Air quality progress is measured by comparing ambient air pollution levels with the appropriate primary and secondary National Ambient Air Quality Standards (NAAQS) for each of six "criteria" air pollutants: total suspended particulates, sulfur dioxide, carbon monoxide, nitrogen dioxide, ozone, and lead. (See Table 1-1.) These standards were prescribed by the Administrator of the U.S. Environmental Protection Agency (EPA) pursuant to the Clean Air Amendments of 1970, as amended. Primary standards protect the public health; secondary standards protect the public welfare, as measured by effects of pollution on vegetation, materials, and visibility.

The National Ambient Air Quality Standards have been achieved in most areas of the country for sulfur dioxide (SO_2), total suspended particulates (TSP),

Table 1-1. National Ambient Air Quality Standards (NAAQS)

Pollutant	Primary (Health Related) Averaging Time	Primary (Health Related) Concentration	Secondary (Welfare Related) Averaging Time	Secondary (Welfare Related) Concentration
TSP	Annual Geometric Mean	75 ug/m³	Annual Geometric Mean	60 ug/m³*
	24-hour	260 ug/m³	24-hour	150 ug/m³
SO_2	Annual Arithmetic Mean	(0.03 ppm) 80 ug/m³	3-hour	(0.50 ppm) 1300 ug/m³
	24-hour	(0.14 ppm) 365 ug/m³		
CO	8-hour	(9 ppm) 10 mg/m³	Same as Primary	
	1-hour	(35 ppm) 40 mg/m³	Same as Primary	
NO_2	Annual Arithmetic Mean	(0.053 ppm) 100 ug/m³	Same as Primary	
O_3	Maximum Daily 1-hour Average	0.12 ppm (235 ug/m³)	Same as Primary	
Pb	Maximum Quarterly Average	1.5 ug/m³	Same as Primary	

*This annual geometric mean is a guide used in assessing implementation plans to achieve the 24-hour standards of 150 ug/m³.

Note: The standards are categorized for long- and short-term exposure. Long-term standards specify an annual or quarterly mean that may not be exceeded; short-term standards specify upper limit values for 1-, 3-, 8-, or 24-hour averages. The short-term standards are not to be exceeded more than once per year. For example, the ozone standard requires that the expected number of days per calendar year with daily maximum hourly concentrations exceeding 0.12 parts per million (ppm) be less than or equal to one.

nitrogen dioxide (NO_2) and lead (Pb). Carbon monoxide (CO) is still a problem in a few metropolitan areas. Ozone (O_3) is the most pervasive problem; however, downward trends have been significant over the past decade, despite some confounding effects of meteorology in 1980 and 1983.

The positive effect of the turnover of the automobile population to new low emissions vehicles in reducing the ozone (O_3) and carbon monoxide (CO)

impacts in the major urban areas of the nation has been clearly demonstrated. The regulatory program that brought this about is the Federal Motor Vehicle Control Program (FMVCP), which sets emissions standards for all new production vehicles. Such standards were made progressively more stringent over the period 1967 to 1977.

With rare exception the national goals to achieve clean air with respect to all of the six criteria pollutants will be accomplished by the end of this decade without further federal control programs. In a few cities some additional control efforts will be required to achieve the O_3 standard by 1990. Los Angeles is the only exception to this projection. Houston and New York City may also be marginal exceptions; however, they have approved State Implementation Plans (SIPs).

The following analysis by the Council on Environmental Quality (CEQ) is based on data compiled on a national, regional, and metropolitan area basis. Additional analyses contained in reports by the U.S. Environmental Protection Agency are also included.

URBAN AIR QUALITY: TRENDS IN THE POLLUTANT STANDARD INDEX

The Pollutant Standard Index (PSI) was developed by an interagency committee in 1976 to provide a common, well-understood index of local air quality with nationwide applicability. This index represents daily measured concentrations of the principal air pollutants, for which National Ambient Air Quality Standards have been established. These standards were set to protect the public health of the sensitive segments of the population with an adequate margin of safety. This PSI index can also be used to analyze trends in urban air quality and to make comparisons among urban areas. The use of the index by local air pollution control agencies was voluntary until 1977 when the Clean Air Act Amendments specified its use by all air pollution control agencies throughout the country.[1] Since 1976, CEQ has used the index as a means of reporting air quality in its annual reports. The relationship between measured air pollution levels, the PSI index number, the health effects descriptors used, and the health effects warnings to the public are shown in Table 1–2. The formulation and methodology of employing the index are described in both CEQ and EPA references.[2]

In the 1982 Annual Report, the Council on Environmental Quality focused on the presentation of PSI data for the most recent (1981) air quality levels in 56 Standard Metropolitan Statistical Areas (SMSAs). Because of the availability of a common data base for at least the last eight years, CEQ is presenting trends in PSI since 1976 for 33 SMSAs. These 33 areas represent the most highly impacted cities historically, and are representative of all geographical regions of the nation. Figure 1–1 displays graphically, for each of the 33 SMSAs, the number of days each year in which the PSI registered in the "unhealthful," "very unhealthful," and "hazardous" range. Days during which air quality fell within the "good" to "moderate" range (i.e., PSI was less than 100) are not plotted. Improvement is thus indicated by a decline in the number of days in which air quality can be described as "unhealthful" or worse.

As the figures show, the downward trend in PSI is dramatic for most of the SMSAs analyzed. The only SMSA showing a upward trend is Anchorage, Alaska,

Table 1-2. Pollutant Standard Index (PSI) Values

PSI Index Value	Air Quality Level	Pollutant Levels					Health Effect Descriptor	General Health Effects	Cautionary Statements
		TSP (24 hour) ug/m³	SO_2 (24 hour) ug/m³	CO (8 hour) ug/m³	O_3 (1 hour) ug/m³	NO_2 (1 hour) ug/m³			
500	Significant harm	100	2620	57.5	1200	3750		Premature death of ill and elderly. Healthy people will experience adverse symptoms that affect their normal activity.	All persons should remain indoors, keeping windows and doors closed. All persons should minimize physical exertion and avoid traffic.
400	Emergency	875	2100	46.0	1000	3000	Hazardous (300 and above)	Premature onset of certain diseases in addition to significant aggravation of symptoms and decreased exercise tolerance in healthy persons.	Elderly and persons with existing diseases should stay indoors and avoid physical exertion. General population should avoid activity.
300	Warning	625	1600	34.0	800	2260	Very Unhealthful (200–299)	Significant aggravation of symptoms and decreased tolerance in persons with heart or lung disease with widespread symptoms in the healthy population.	Elderly and persons with existing heart or lung disease should stay indoors and reduce physical activity.

200	Alert	375	800	17.0	400[c]	1130	Unhealthful (100-199)	Mild aggravation of symptoms in susceptible persons with irritation symptoms in the healthy population.	Persons with existing heart or respiratory ailments should reduce physical exertion and outdoor activity.
100	NAAQS	260	365	10.0	240	NA[a]	Moderate		
50	50% of NAAQS	75[b]	80[b]	5.0	120	NA[a]	Moderate		
0		0	0	0	0	NA[a]	Good		

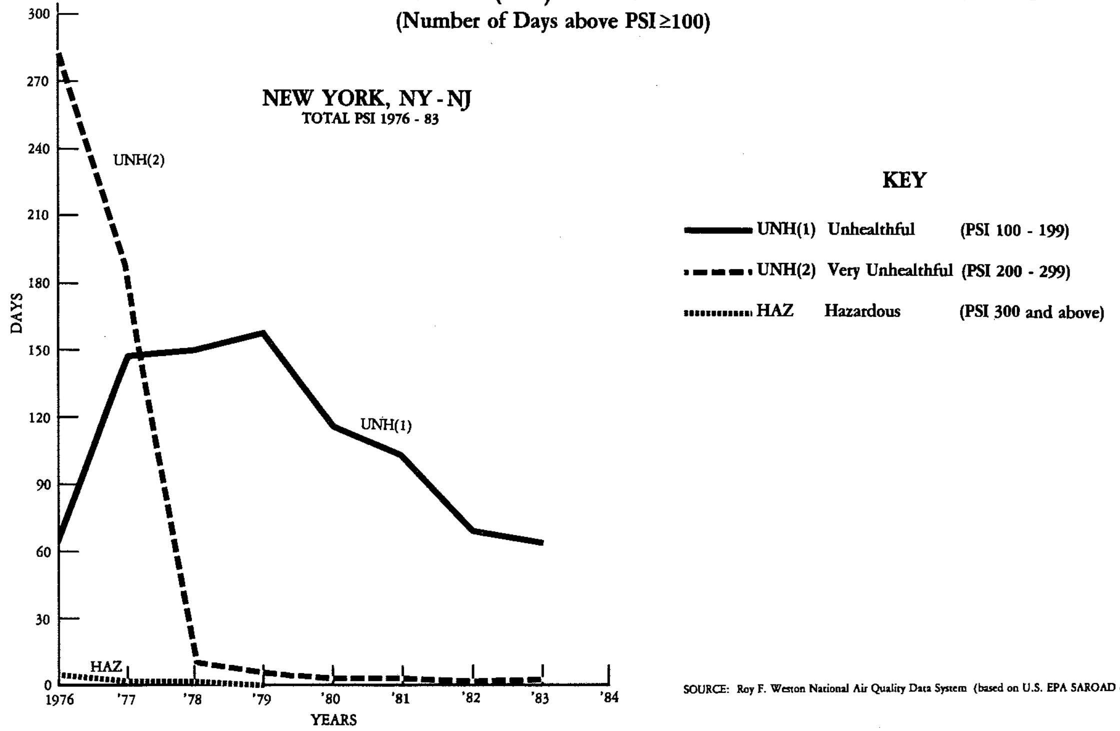
[a]No index values reported at concentration levels below those specified by "Alert Level" criteria.
[b]Annual primary NAAQS.
[c]400 ug/m^3 was used instead of the ozone Alert Level of 200 ug/m^3.

Source: U.S. Environmental Protection Agency, "Guidelines for Public Reporting of Daily Air Quality — Pollutant Standard Index," 1976.

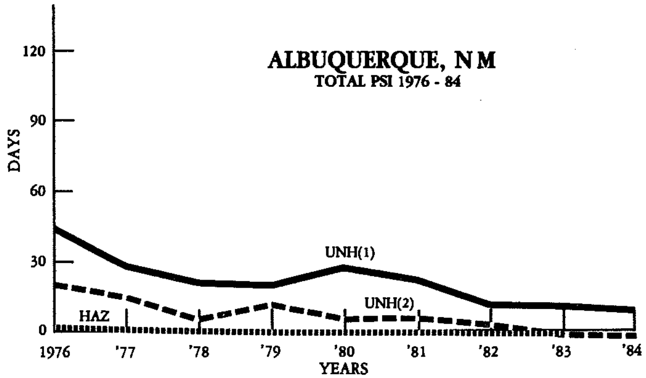
FIGURE 1-1

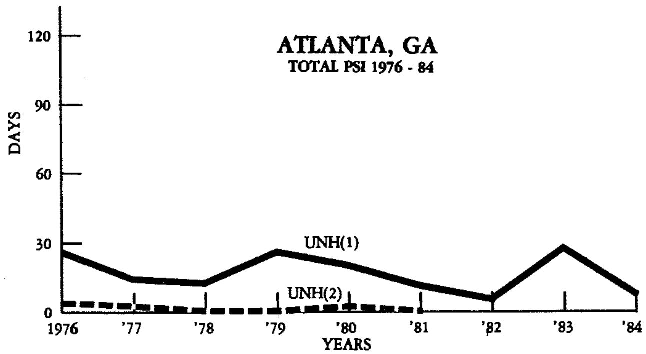
POLLUTANT STANDARD INDEX (PSI) TRENDS IN SELECTED U. S. CITIES

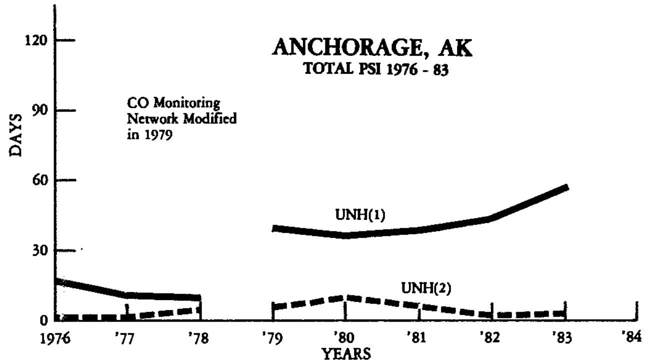
(Number of Days above PSI ≥100)

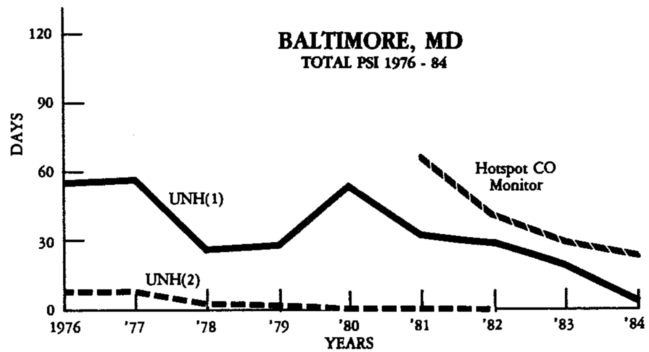


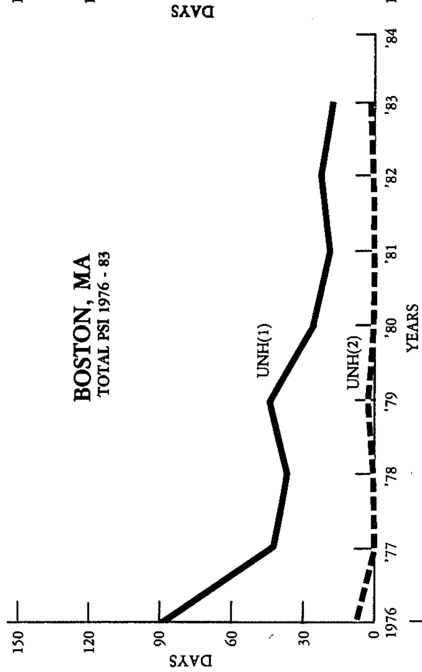
SOURCE: Roy F. Weston National Air Quality Data System (based on U.S. EPA SAROAD data)

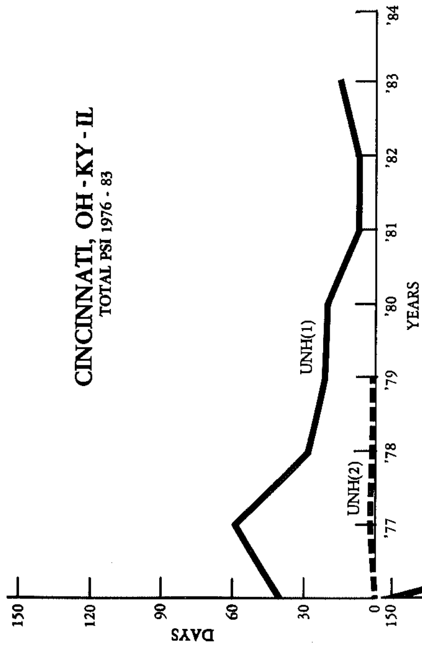

ALBUQUERQUE, N M
TOTAL PSI 1976 - 84
DAYS
120
90
60
30
0
UNH(1)
UNH(2)
HAZ
1976
'77
'78
'79
'80
'81
'82
'83
'84
YEARS

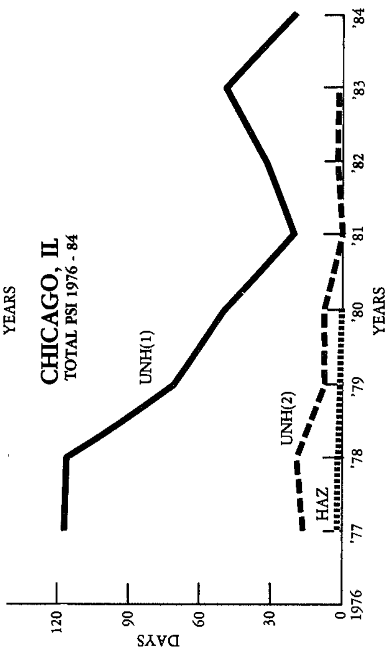

ATLANTA, GA
TOTAL PSI 1976 - 84
DAYS
120
90
60
30
0
UNH(1)
UNH(2)
1976
'77
'78
'79
'80
'81
'82
'83
'84
YEARS

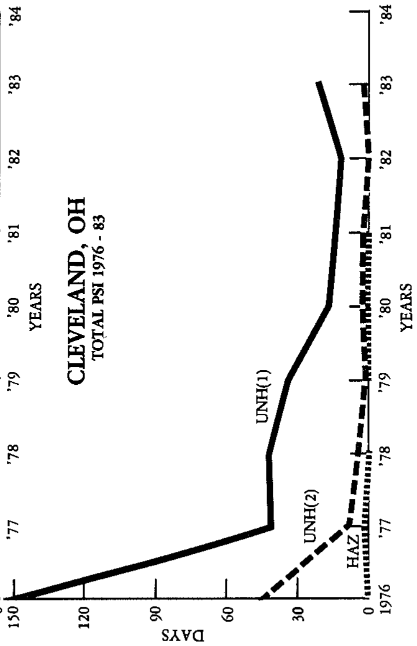

ANCHORAGE, AK
TOTAL PSI 1976 - 83
CO Monitoring
Network Modified
in 1979
DAYS
120
90
60
30
0
UNH(1)
UNH(2)
1976
'77
'78
'79
'80
'81
'82
'83
'84
YEARS

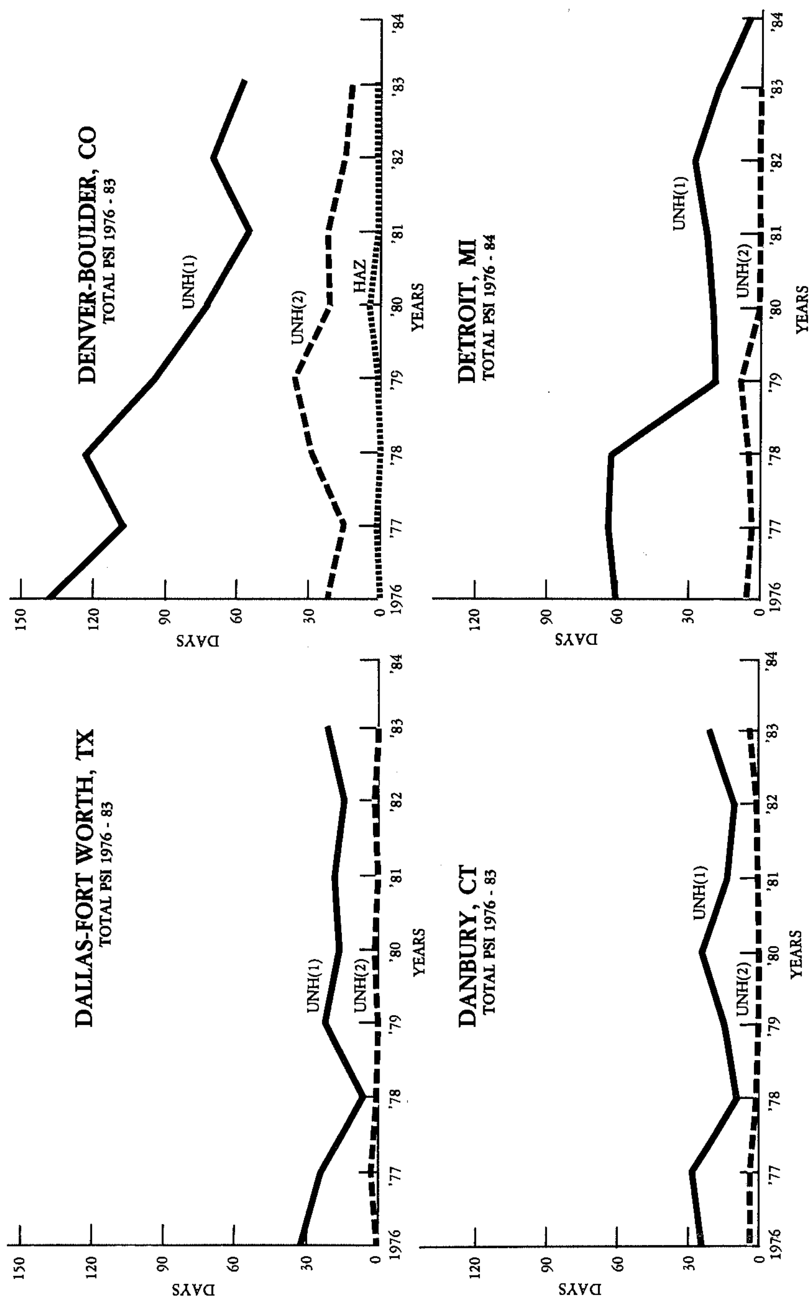

BALTIMORE, MD
TOTAL PSI 1976 - 84
Hotspot CO
Monitor
DAYS
120
90
60
30
0
UNH(1)
UNH(2)
1976
'77
'78
'79
'80
'81
'82
'83
'84
YEARS

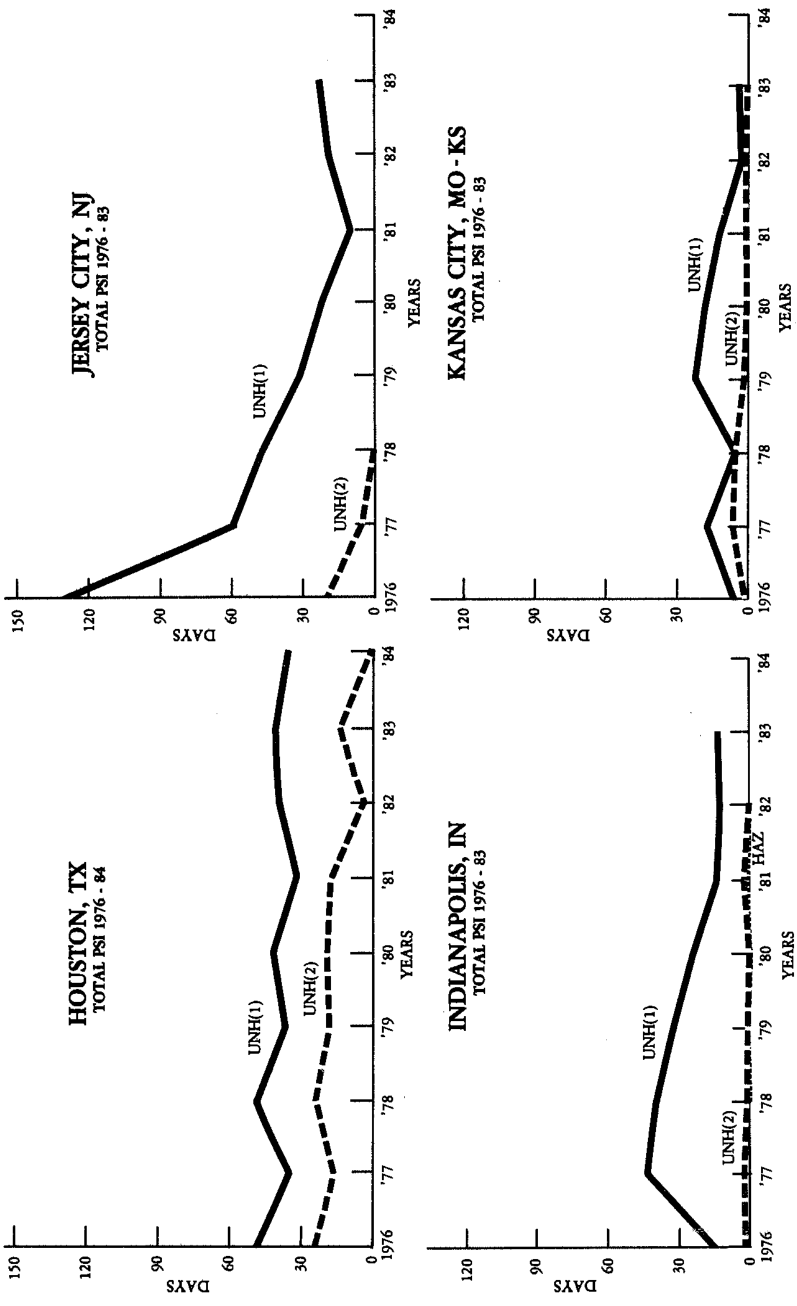

BOSTON, MA
TOTAL PSI 1976 - 83
DAYS
150
120
90
60
30
0
1976
'77
'78
'79
'80
'81
'82
'83
'84
YEARS
UNH(1)
UNH(2)

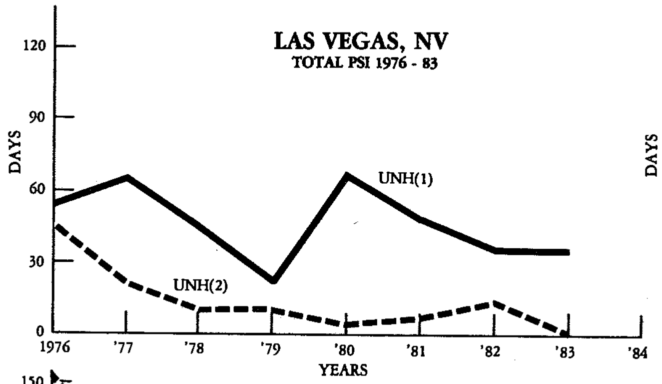

CINCINNATI, OH - KY - IL
TOTAL PSI 1976 - 83
DAYS
150
120
90
60
30
0
1976
'77
'78
'79
'80
'81
'82
'83
'84
YEARS
UNH(1)
UNH(2)

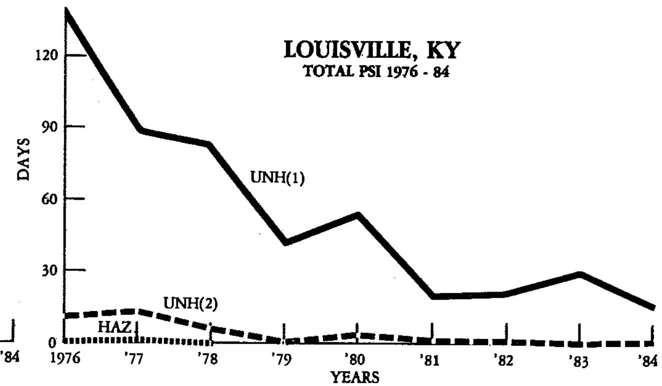

CHICAGO, IL
TOTAL PSI 1976 - 84
DAYS
120
90
60
30
0
1976
'77
'78
'79
'80
'81
'82
'83
'84
YEARS
UNH(1)
UNH(2)
HAZ

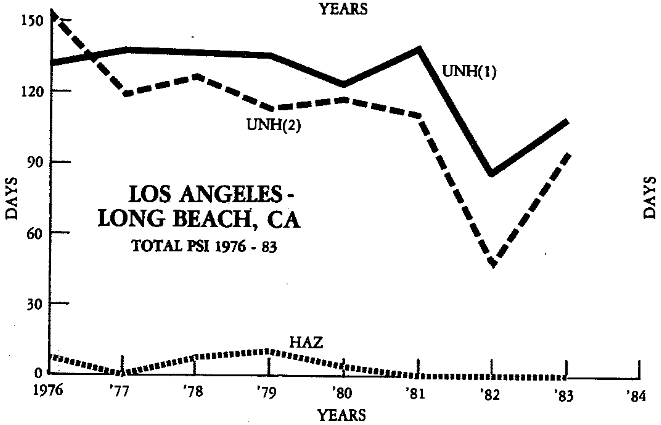

CLEVELAND, OH
TOTAL PSI 1976 - 83
DAYS
150
120
90
60
30
0
1976
'77
'78
'79
'80
'81
'82
'83
'84
YEARS
UNH(1)
UNH(2)
HAZ

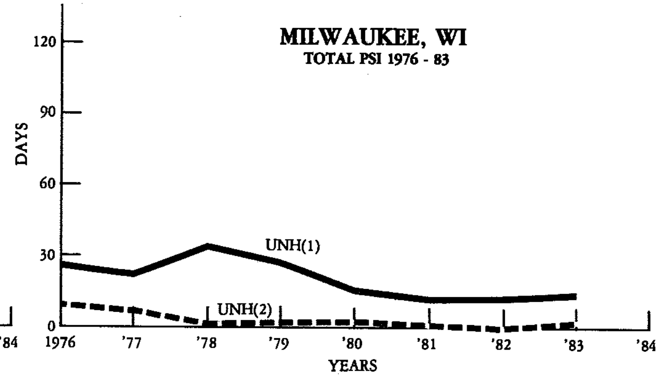

DALLAS-FORT WORTH, TX
TOTAL PSI 1976 - 83
DENVER-BOULDER, CO
TOTAL PSI 1976 - 83
DANBURY, CT
TOTAL PSI 1976 - 83
DETROIT, MI
TOTAL PSI 1976 - 84
UNH(1)
UNH(2)
HAZ
DAYS
YEARS
150
120
90
60
30
0
1976
'77
'78
'79
'80
'81
'82
'83
'84

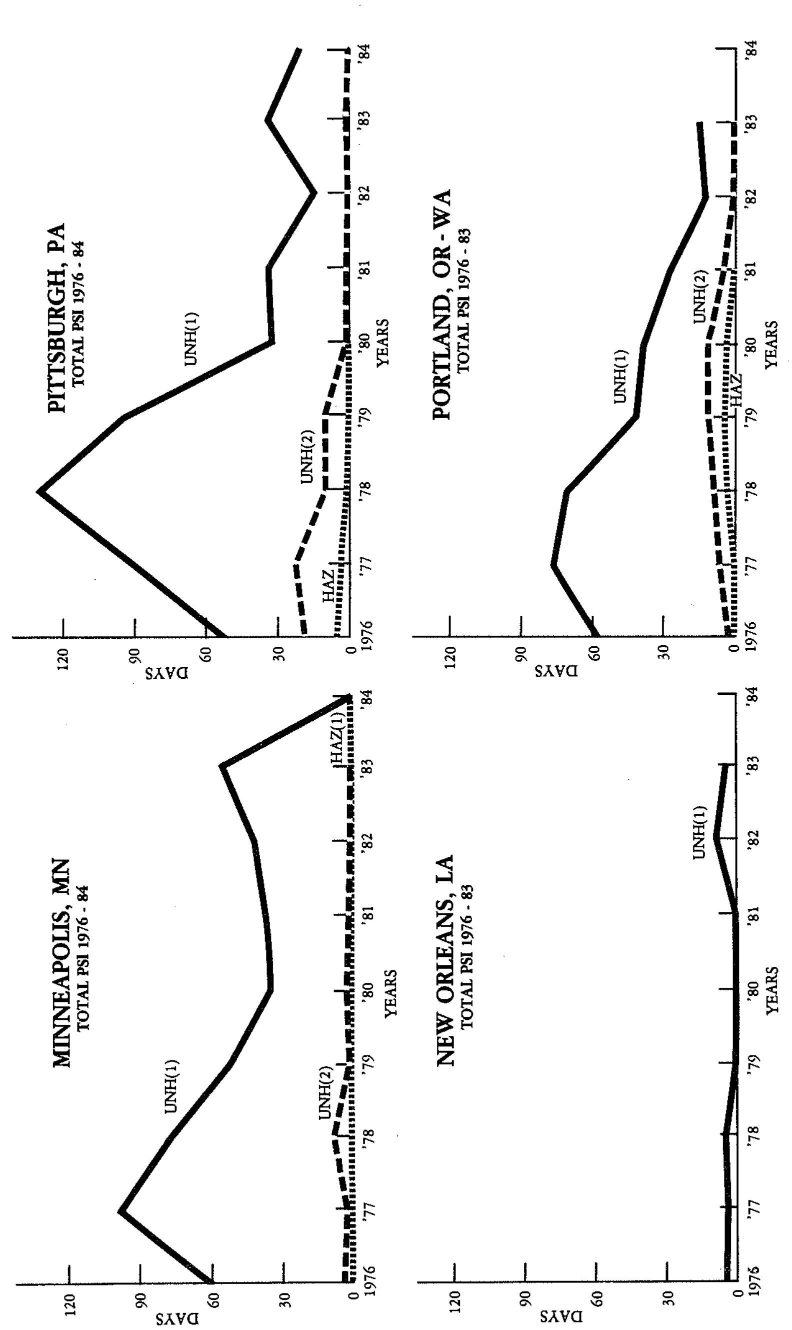

HOUSTON, TX
TOTAL PSI 1976 - 84
JERSEY CITY, NJ
TOTAL PSI 1976 - 83
INDIANAPOLIS, IN
TOTAL PSI 1976 - 83
KANSAS CITY, MO - KS
TOTAL PSI 1976 - 83
UNH(1)
UNH(2)
HAZ
DAYS
YEARS
150
120
90
60
30
0
1976
'77
'78
'79
'80
'81
'82
'83
'84


LAS VEGAS, NV
TOTAL PSI 1976 - 83
DAYS
120
90
60
30
0
UNH(1)
UNH(2)
1976
'77
'78
'79
'80
'81
'82
'83
'84
YEARS


LOUISVILLE, KY
TOTAL PSI 1976 - 84
DAYS
120
90
60
30
0
UNH(1)
UNH(2)
HAZ
1976
'77
'78
'79
'80
'81
'82
'83
'84
YEARS


LOS ANGELES -
LONG BEACH, CA
TOTAL PSI 1976 - 83
DAYS
150
120
90
60
30
0
UNH(1)
UNH(2)
HAZ
1976
'77
'78
'79
'80
'81
'82
'83
'84
YEARS


MILWAUKEE, WI
TOTAL PSI 1976 - 83
DAYS
120
90
60
30
0
UNH(1)
UNH(2)
1976
'77
'78
'79
'80
'81
'82
'83
'84
YEARS



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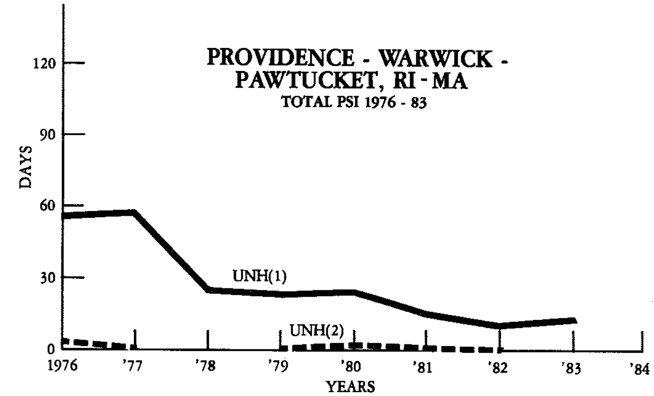
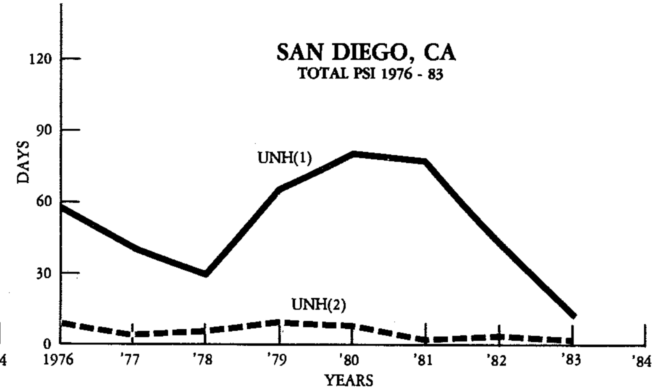
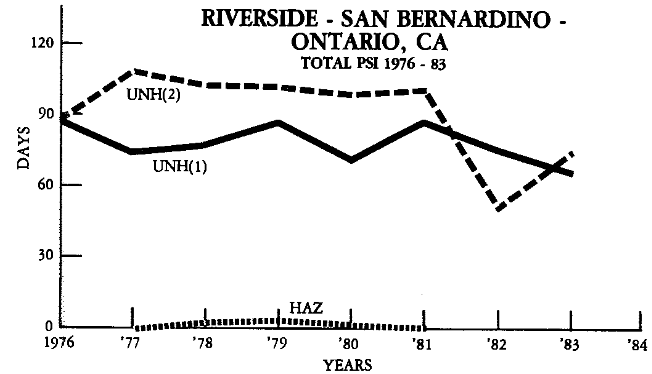
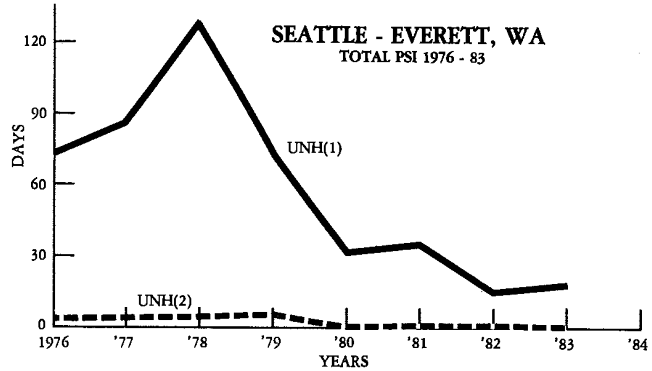
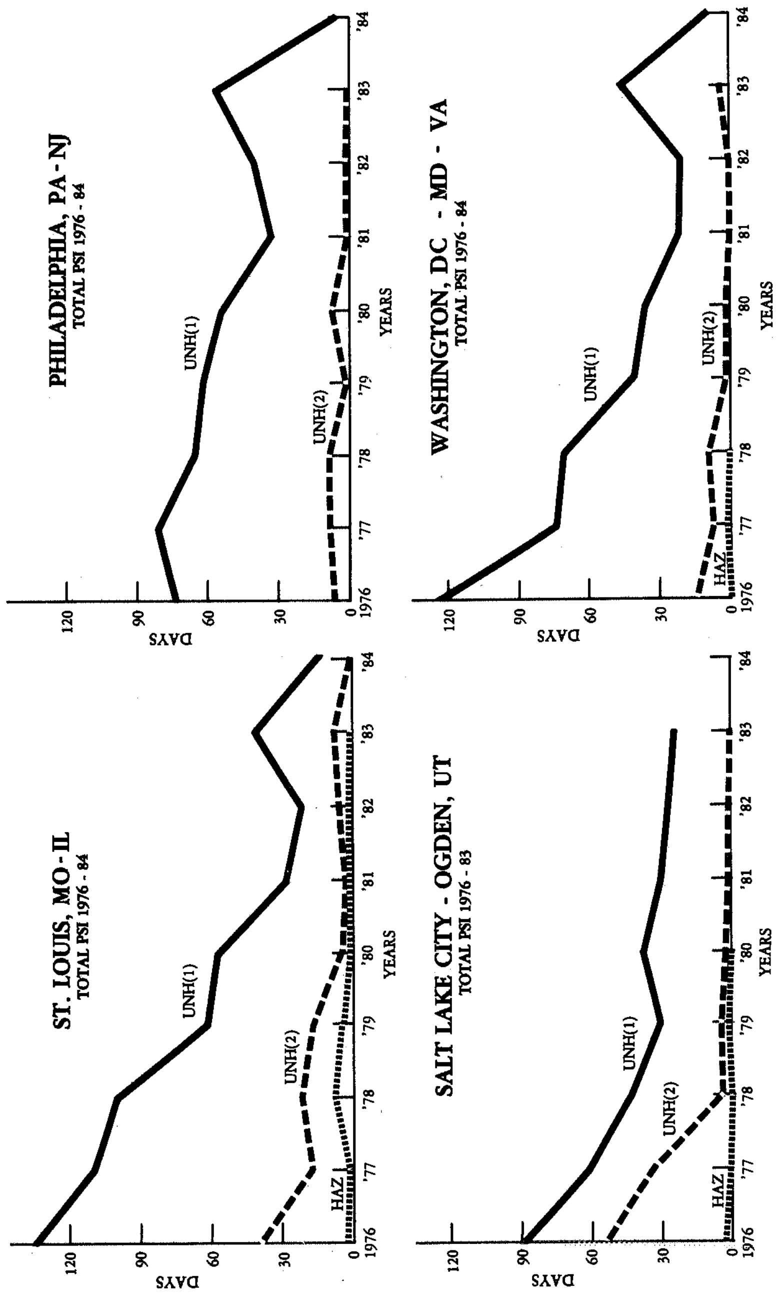

PROVIDENCE - WARWICK - PAWTUCKET, RI - MA
TOTAL PSI 1976 - 83
DAYS
120
90
60
30
0
UNH(1)
UNH(2)
1976
'77
'78
'79
'80
'81
'82
'83
'84
YEARS


SAN DIEGO, CA
TOTAL PSI 1976 - 83
DAYS
120
90
60
30
0
UNH(1)
UNH(2)
1976
'77
'78
'79
'80
'81
'82
'83
'84
YEARS


RIVERSIDE - SAN BERNARDINO - ONTARIO, CA
TOTAL PSI 1976 - 83
DAYS
120
90
60
30
0
UNH(2)
UNH(1)
HAZ
1976
'77
'78
'79
'80
'81
'82
'83
'84
YEARS


SEATTLE - EVERETT, WA
TOTAL PSI 1976 - 83
DAYS
120
90
60
30
0
UNH(1)
UNH(2)
1976
'77
'78
'79
'80
'81
'82
'83
'84
YEARS



P00000123058

which has a unique CO problem related to parked, idling cars in the wintertime. To prevent freezing, cars are left running at curbside, which causes CO buildup. The upturn evident for 1983 in some SMSAs is due to the abnormally hot weather experienced in many of these cities in that year, and the resultant effect on ozone levels. Data for 1984, which were obtained directly from state and local agencies for 12 of the 33 cities studied, showed in every case a return to the downward trend.

The downward trends over this period are attributable to the rapid decline in mobile-source CO and volatile organic compound (VOC) emissions. Volatile organic compound (VOC) emissions are synonymous with hydrocarbon (HC) and nonmethane hydrocarbon (NMHC) emissions which have been referred to in historical references to the O_3 problem. CO air quality problems are due entirely to mobile-source emissions, while VOC emissions (which are the precursors to O_3 formation) are about half from mobile sources.

To illustrate how the PSI trends have been influenced by individual pollutant trends, four of the 33 cities were selected for analysis on a pollutant-by-pollutant basis. These cities — Chicago, Philadelphia, St. Louis and Washington, D.C. — represent a good cross-section of the historical patterns of how and which pollutants affected air quality over the 1976–1984 timeframe. (See Figure 1–2.) Each graph shows how each pollutant contributed to the total number of days per year when PSI was above 100, or "unhealthful." For example, Chicago in 1977 had a total of 117 unhealthful days. Of this number, 86 were associated with carbon monoxide (CO), 17 were due to ozone (O_3), 2 due to sulfur dioxide (SO_2), and 12 due to particulates (TSP).

It can be seen that CO and O_3 are the predominant pollutants "driving" the PSI in all four cities. TSP, except in St. Louis in earlier years, and SO_2 rarely drive the index. The downward trends in the PSI in most of these cities have been mainly influenced by the drop in CO levels from 1976 to 1981. More recently, from 1981 to 1984, the index is mainly driven by O_3.

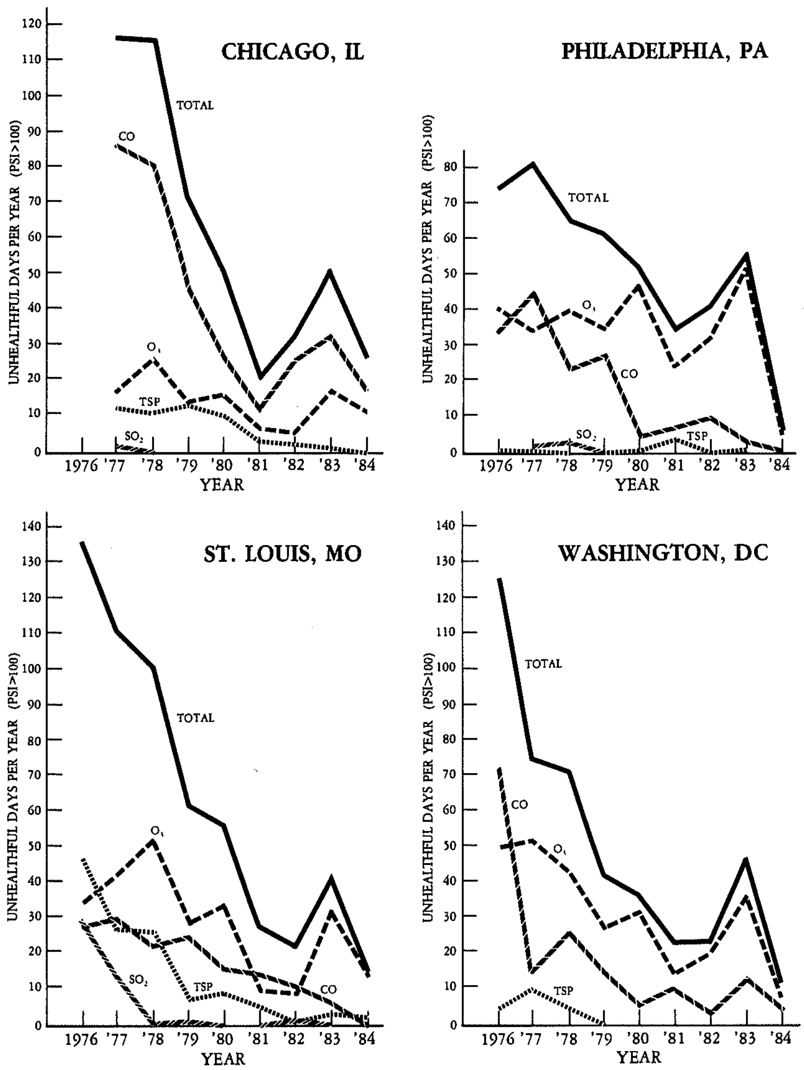
STATUS AND TRENDS FOR INDIVIDUAL AIR POLLUTANTS

As previously stated, the national standards for SO_2, TSP, NO_2, and lead have been achieved almost everywhere in the nation. The Los Angeles Basin is the most notable exception with respect to NO_2. Therefore, this annual report will focus on the remaining O_3 and CO problems. Some EPA data will be presented relative to these other three criteria pollutants and lead, but the reader is referred to the 1982 CEQ Annual Report, which discusses the achievement of the national goals for the pollutants SO_2, TSP, and NO_2.

The O_3 problem is caused by VOC emissions from mobile and stationary sources. The predominant strategy that has been implemented nationwide to reduce O_3 levels is to reduce mobile source emissions of VOC through the Federal Motor Vehicle Control Program (FMVCP), which imposed progressively more stringent emission limits on new cars and trucks. Additionally, controls have been retrofitted on existing classes of industrial VOC emission sources, such as refineries, petrochemical manufacturing, and coating operations and printing. Some cities have also been required to implement auto inspection and maintenance programs and transportation control measures, both of which may be of incremental benefit. These latter programs will require further study to

FIGURE 1-2

PSI TRENDS BY POLLUTANT FOR FOUR SMSAs



ascertain the continued need for these programs and their effectiveness in improving O_3 air quality.

The CO problem is totally related to mobile-source emissions and is confined to central city streets where vehicle congestion occurs during the morning and afternoon commute periods. It is projected that the problem will be alleviated by 1990 solely through the FMVCP, although a few monitoring sites may still show several exceedances by the legally mandated attainment date of December 31, 1987.

Ozone (O_3)

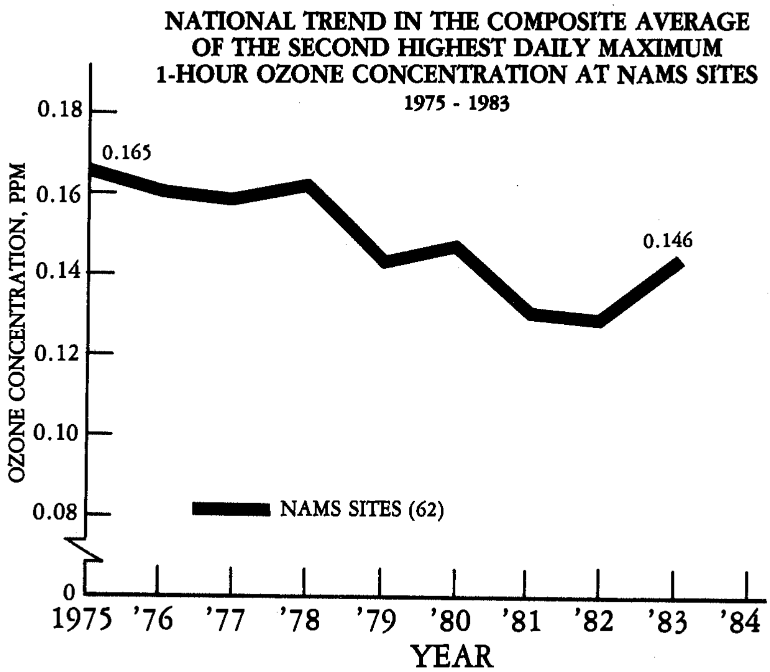
The NAAQS for O_3 or ozone is defined in terms of a daily maximum hourly value for the day and specifies that the expected number of days per year with observations greater than 0.12 parts per million (ppm) should not be greater than one day per year on the average. Because ambient ozone concentrations are usually higher during the summer when sunlight stimulates the production of ozone from the interaction with hydrocarbons and nitrogen oxides, some ozone monitors measure ozone concentrations only during the hotter months of the year. The length of this ozone season varies from one area of the country to another, but May through October is fairly typical. Southern and southwest states tend to monitor the entire year, while the northern states have a shorter monitoring season, May through September. The effects of meteorology and the year-to-year influence on ozone levels are discussed later.

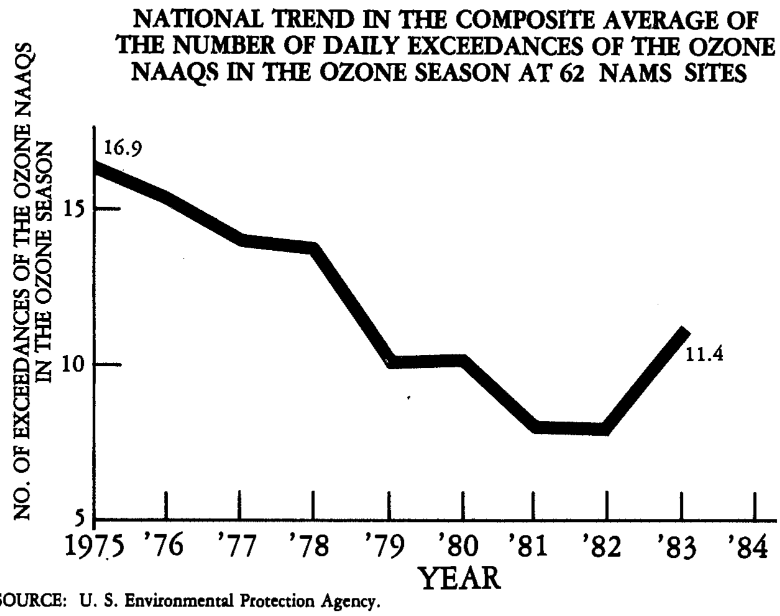
EPA has reported the national ozone trends using the composite data from 62 trends sites from the official National Air Monitoring System (NAMS) network. These data, based on trends in both annual average concentration of O_3 and the number of days in which the 0.12 ppm standard was exceeded, are shown in Figure 1–3. EPA points out that some of the downward trend may be attributable to a change in calibration methods by some local agencies in 1978 and 1979, and that the reverse trend in 1983 may have been caused by the extremely hot weather experienced across the U.S. in that year in combination with a projected nationwide increase in VOC emissions from 1982 to 1983.[3]

CEQ examined the regional ozone trends using EPA's regional breakdown, but isolating the Los Angeles Basin, for the years 1976–1983. These 10 EPA regions are shown on the map in Figure 1–4. In order to remove the influence of Los Angeles, which dominates the ozone impact problem in Region IX, the six counties that make up the Los Angeles Basin were classified into Region 9B: Los Angeles Co., Ventura Co., Orange Co., San Bernardino Co., Santa Barbara Co., and Riverside Co. The data for the rest of California, Arizona, and Nevada were included in Region 9A. Region X (Washington, Oregon, Idaho, and Alaska) is excluded because this region does not experience any significant O_3 impacts. Figure 1–5 shows the actual trends for three of the regions. Figure 1–6 shows the underlying trends based on regression analysis. The correlations for the regions shown are excellent. Region 9A, which is not shown, is the only region not showing a significant downward trend among all of the regions analyzed. The inconsistent trend line for Region 9A in Figure 1–5 may be influenced by the fact that the air quality data for San Diego and other regions surrounding the Los Angeles Basin are influenced by ozone transport from the Basin.

CEQ also examined the O_3 trends on a city-by-city basis. In general, one area of a city is usually more highly impacted than others: the area downwind of the city where the urban plume traverses on a smoggy day. For the purpose of this analysis, CEQ used the county within the SMSA in which the most highly impacted monitors are located. Data were analyzed for 19 cities, as shown in Figure 1–7. These data again clearly show the downward trend in ozone and reinforce the fact that the 1983 data were anomalous due to meteorology, even though the impact on the true trend was dampened by the use of the three-year running averages.

FIGURE 1-3

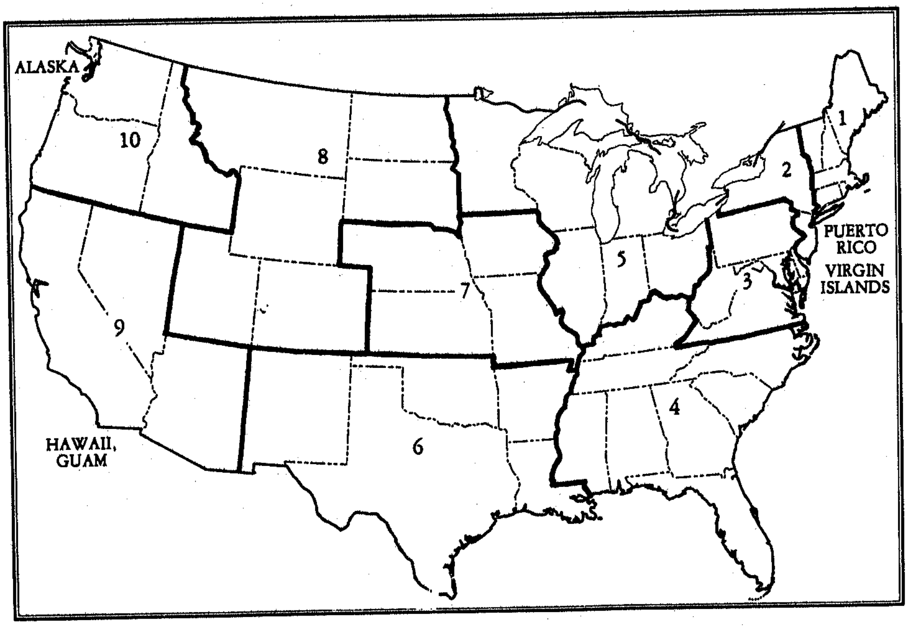




SOURCE: U. S. Environmental Protection Agency.

FIGURE 1-4

TEN REGIONS OF THE U. S. ENVIRONMENTAL PROTECTION AGENCY

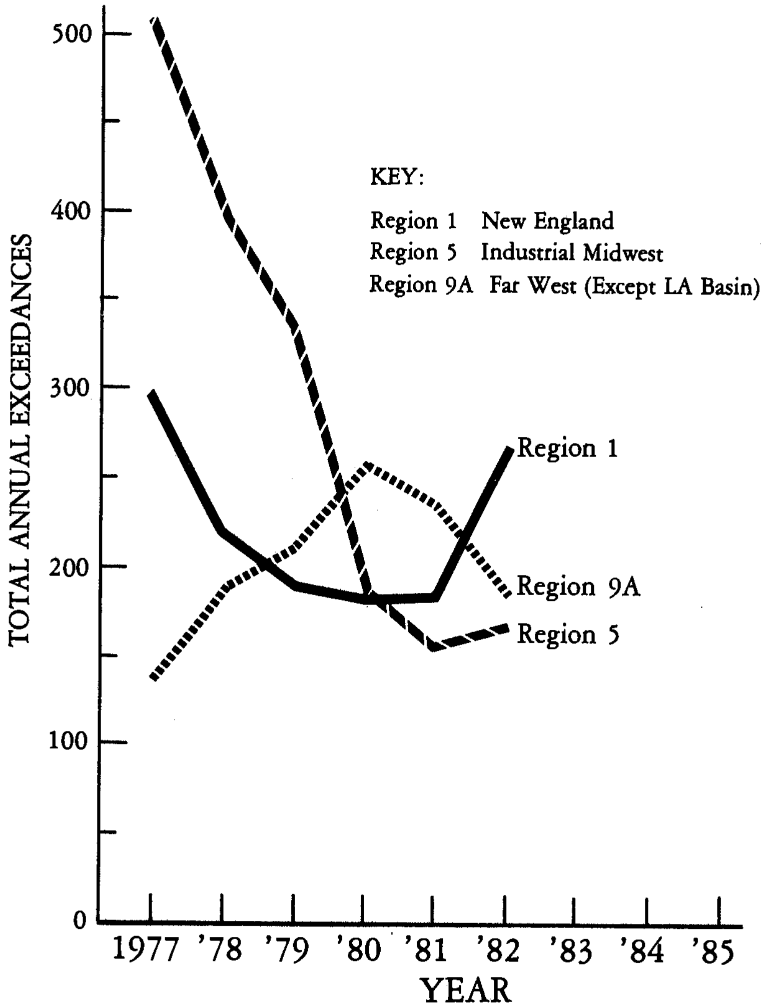


SOURCE: U. S. Environmental Protection Agency.

FIGURE 1-5

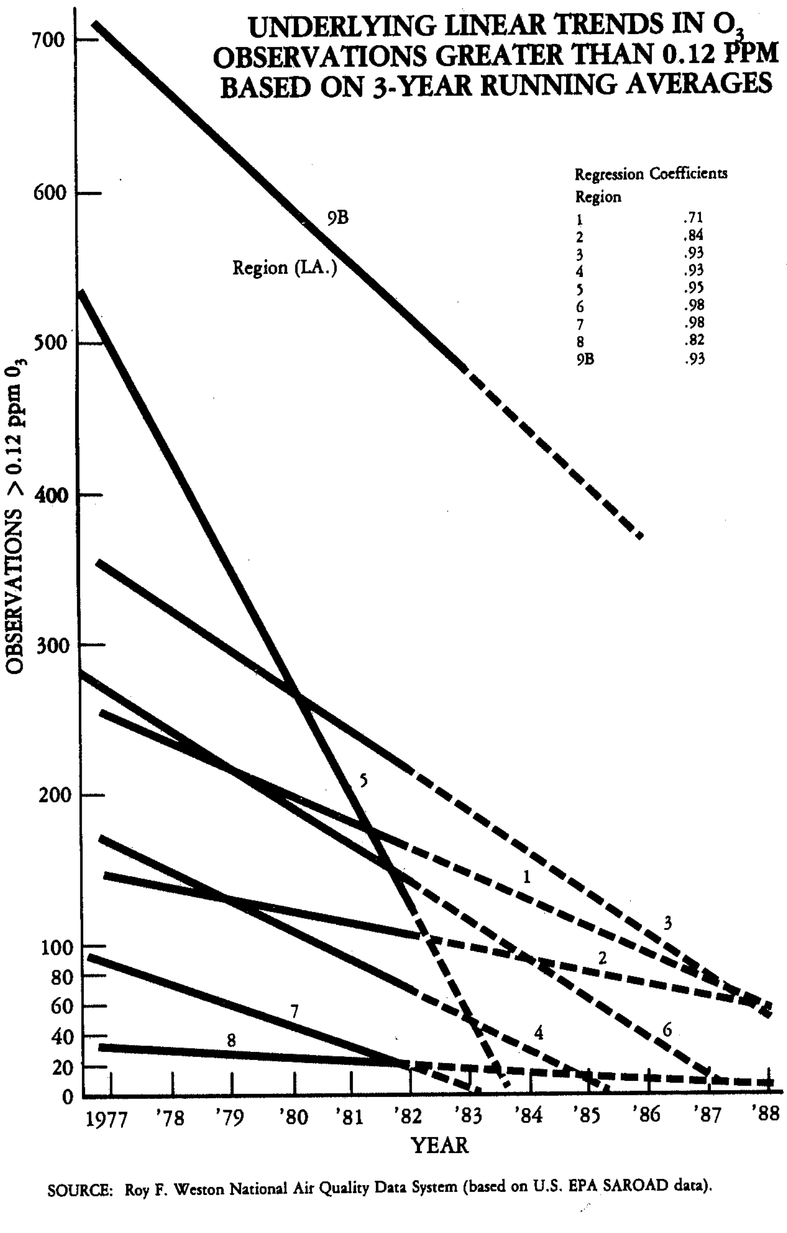
TRENDS IN REGIONAL O_3 AIR QUALITY TOTAL EXCEEDANCES PER YEAR

3-Year Running Averages



P00000123064

FIGURE 1-6

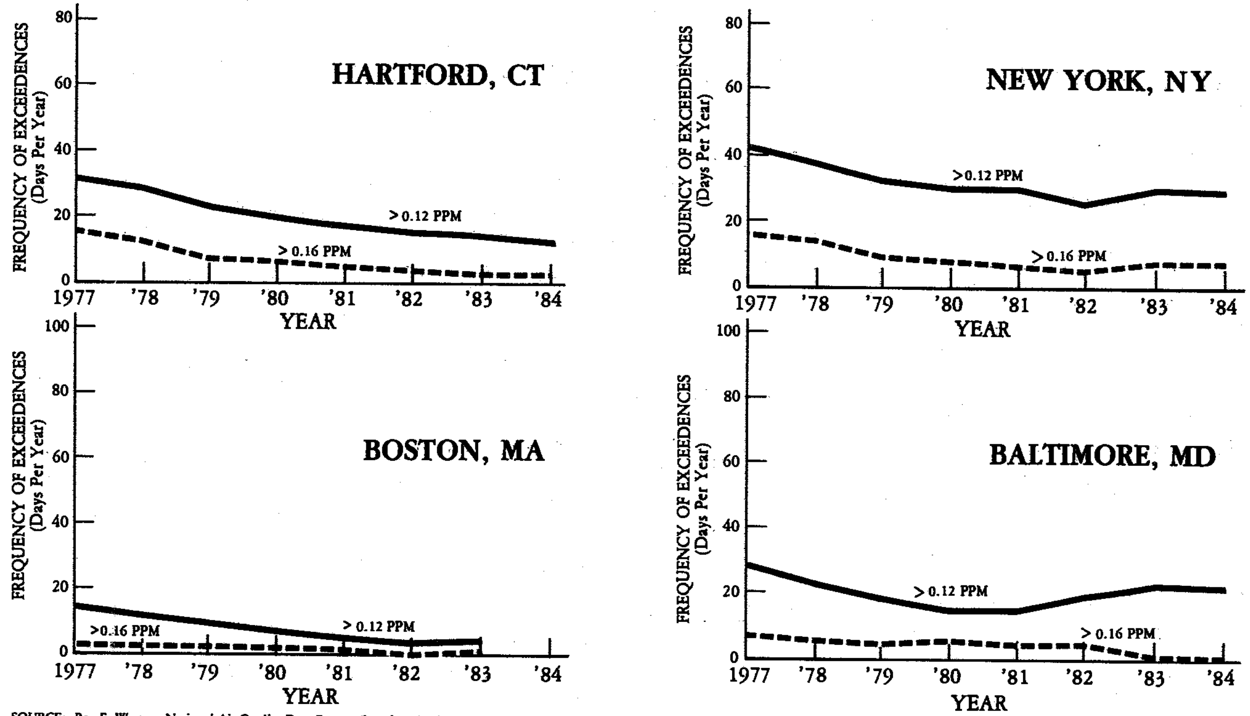


SOURCE: Roy F. Weston National Air Quality Data System (based on U.S. EPA SAROAD data).

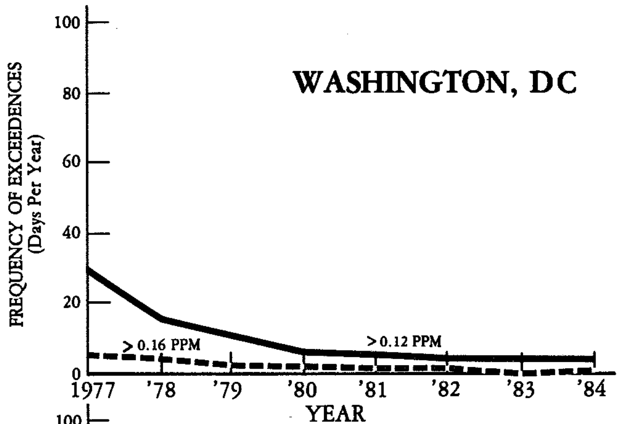
FIGURE 1 - 7

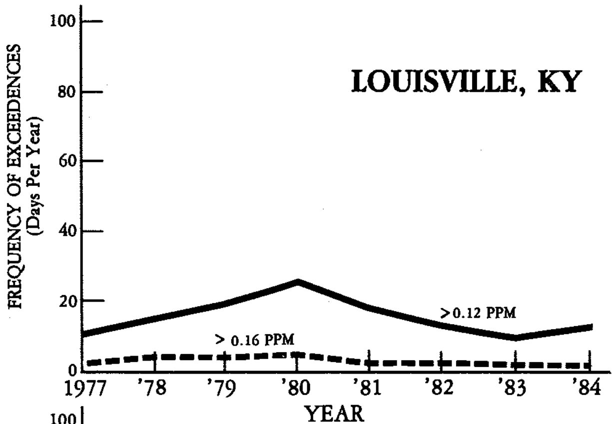
OZONE (O_3) TRENDS BY SMSA

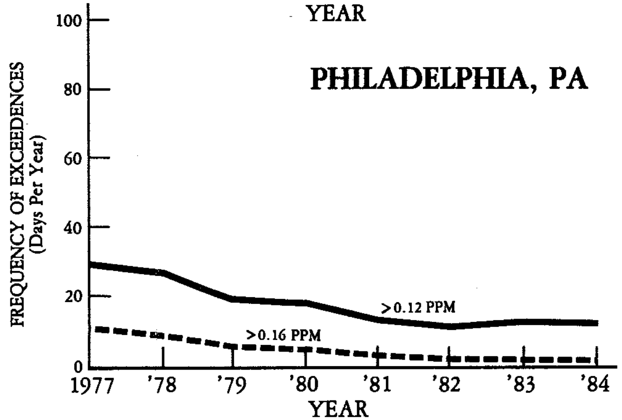
(3-Year Running Averages)

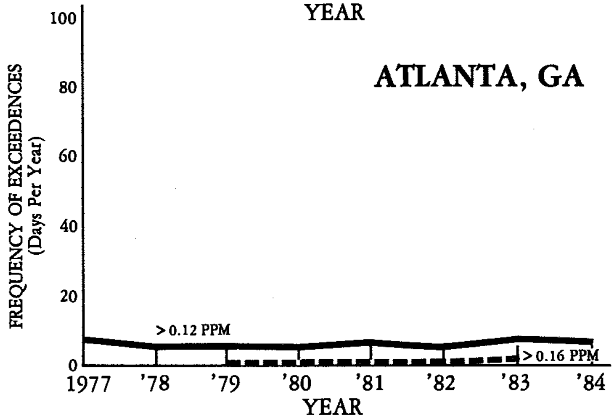


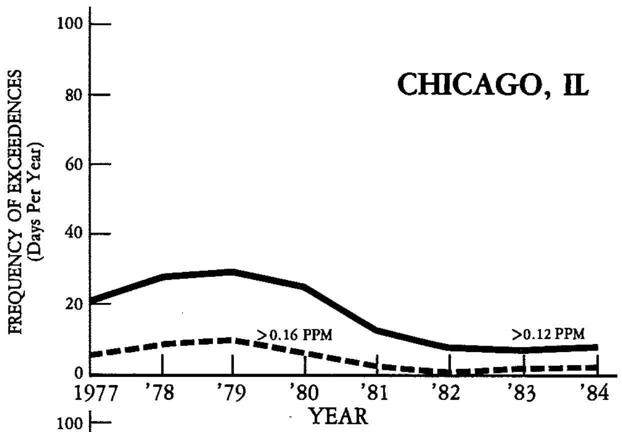
SOURCE: Roy F. Weston, National Air Quality Data System (based on U. S. EPA SAROAD data).

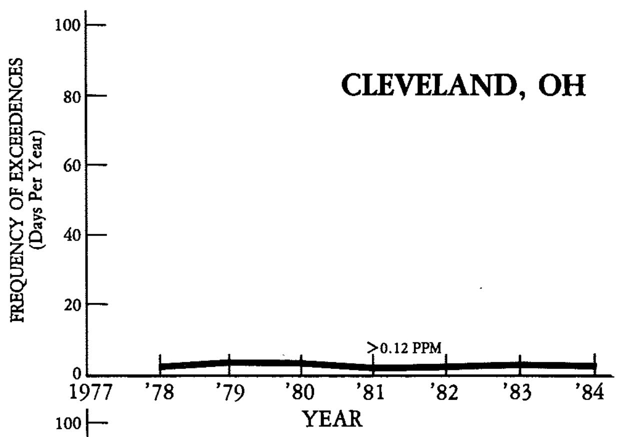

WASHINGTON, DC
FREQUENCY OF EXCEEDENCES
(Days Per Year)
100
80
60
40
20
0
> 0.16 PPM
> 0.12 PPM
1977
'78
'79
'80
'81
'82
'83
'84
YEAR

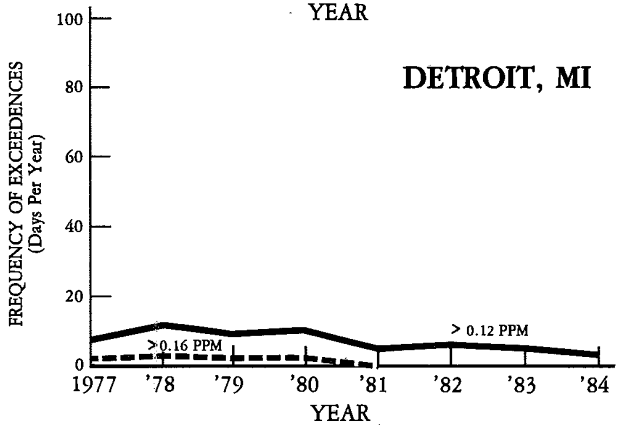

LOUISVILLE, KY
FREQUENCY OF EXCEEDENCES
(Days Per Year)
100
80
60
40
20
0
> 0.16 PPM
> 0.12 PPM
1977
'78
'79
'80
'81
'82
'83
'84
YEAR

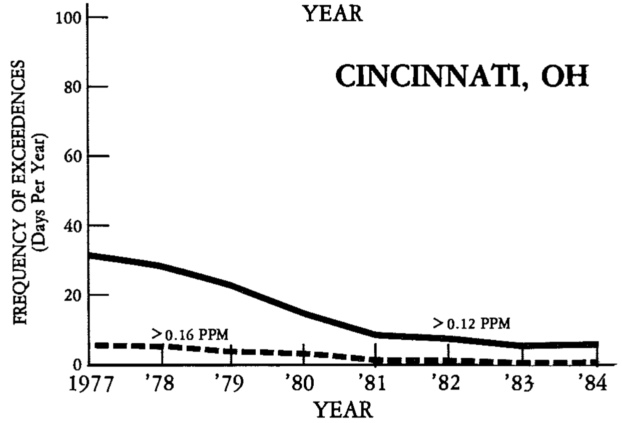

PHILADELPHIA, PA
FREQUENCY OF EXCEEDENCES
(Days Per Year)
100
80
60
40
20
0
> 0.12 PPM
> 0.16 PPM
1977
'78
'79
'80
'81
'82
'83
'84
YEAR

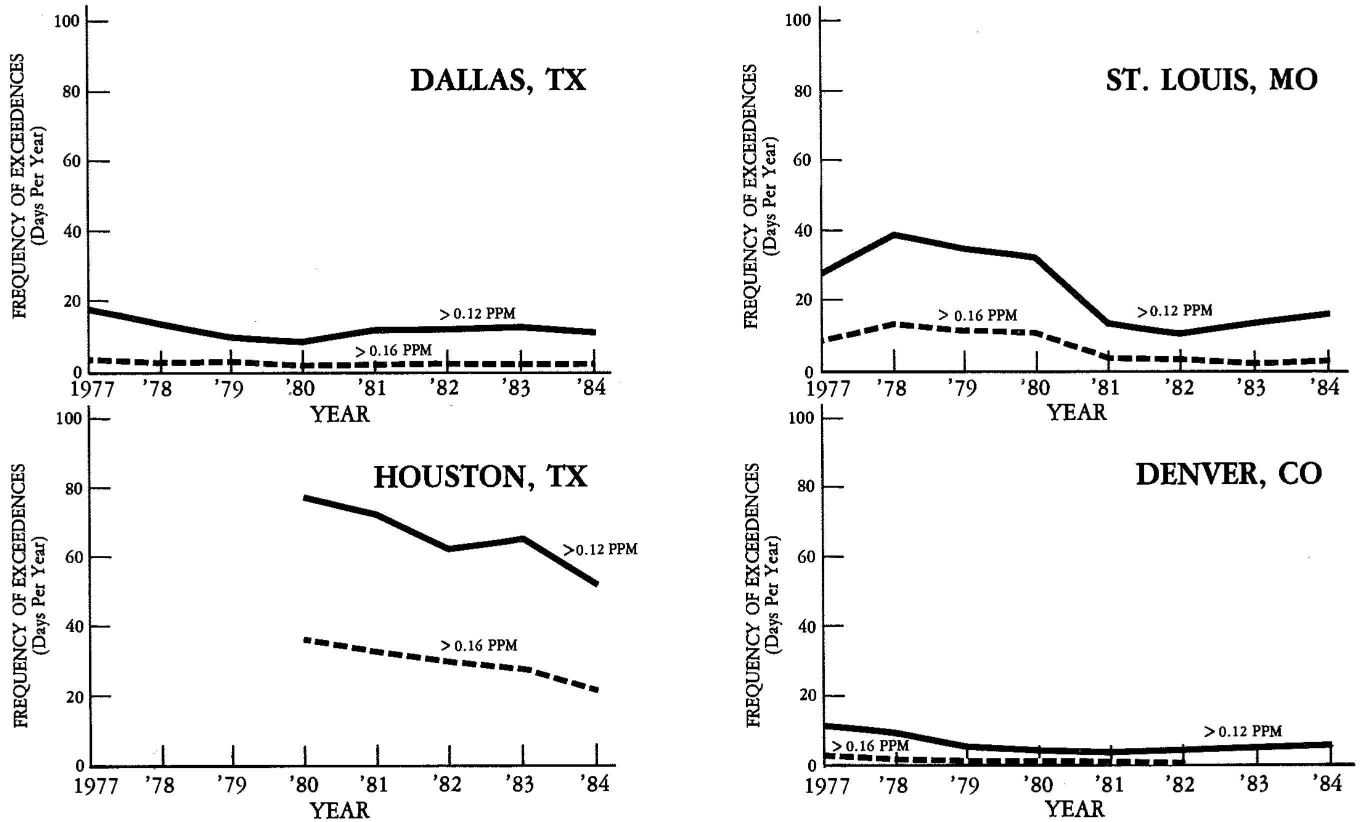

ATLANTA, GA
FREQUENCY OF EXCEEDENCES
(Days Per Year)
100
80
60
40
20
0
> 0.12 PPM
> 0.16 PPM
1977
'78
'79
'80
'81
'82
'83
'84
YEAR

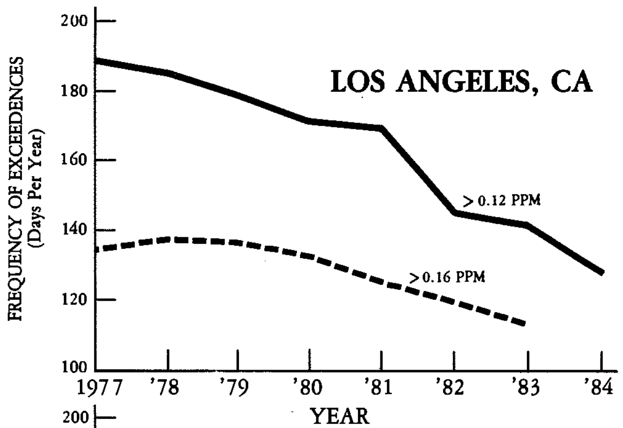

CHICAGO, IL
FREQUENCY OF EXCEEDENCES
(Days Per Year)
100
80
60
40
20
0
>0.16 PPM
>0.12 PPM
1977
'78
'79
'80
'81
'82
'83
'84
YEAR

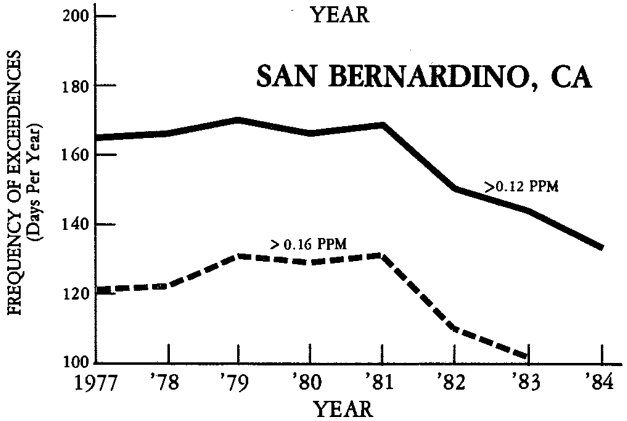

CLEVELAND, OH
FREQUENCY OF EXCEEDENCES
(Days Per Year)
100
80
60
40
20
0
>0.12 PPM
1977
'78
'79
'80
'81
'82
'83
'84
YEAR


DETROIT, MI
FREQUENCY OF EXCEEDENCES
(Days Per Year)
100
80
60
40
20
0
>0.16 PPM
> 0.12 PPM
1977
'78
'79
'80
'81
'82
'83
'84
YEAR


CINCINNATI, OH
FREQUENCY OF EXCEEDENCES
(Days Per Year)
100
80
60
40
20
0
>0.16 PPM
>0.12 PPM
1977
'78
'79
'80
'81
'82
'83
'84
YEAR


DALLAS, TX
FREQUENCY OF EXCEEDENCES (Days Per Year)
100
80
60
40
20
0
1977 '78 '79 '80 '81 '82 '83 '84
YEAR
> 0.12 PPM
> 0.16 PPM
ST. LOUIS, MO
FREQUENCY OF EXCEEDENCES (Days Per Year)
100
80
60
40
20
0
1977 '78 '79 '80 '81 '82 '83 '84
YEAR
> 0.12 PPM
> 0.16 PPM
HOUSTON, TX
FREQUENCY OF EXCEEDENCES (Days Per Year)
100
80
60
40
20
0
1977 '78 '79 '80 '81 '82 '83 '84
YEAR
>0.12 PPM
> 0.16 PPM
DENVER, CO
FREQUENCY OF EXCEEDENCES (Days Per Year)
100
80
60
40
20
0
1977 '78 '79 '80 '81 '82 '83 '84
YEAR
> 0.12 PPM
> 0.16 PPM


LOS ANGELES, CA
FREQUENCY OF EXCEEDENCES
(Days Per Year)
200
180
160
140
120
100
> 0.12 PPM
> 0.16 PPM
1977
'78
'79
'80
'81
'82
'83
'84
YEAR


SAN BERNARDINO, CA
FREQUENCY OF EXCEEDENCES
(Days Per Year)
200
180
160
140
120
100
>0.12 PPM
> 0.16 PPM
1977
'78
'79
'80
'81
'82
'83
'84
YEAR

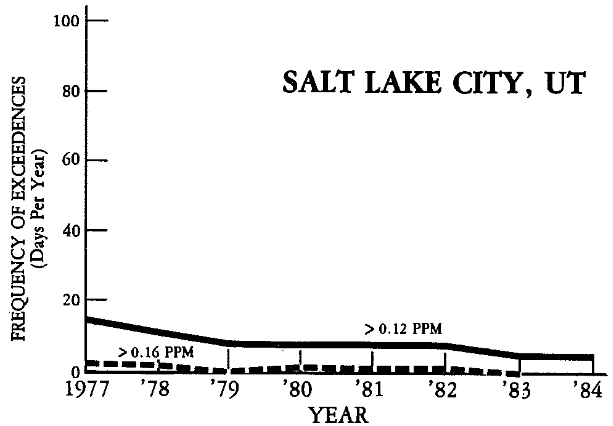
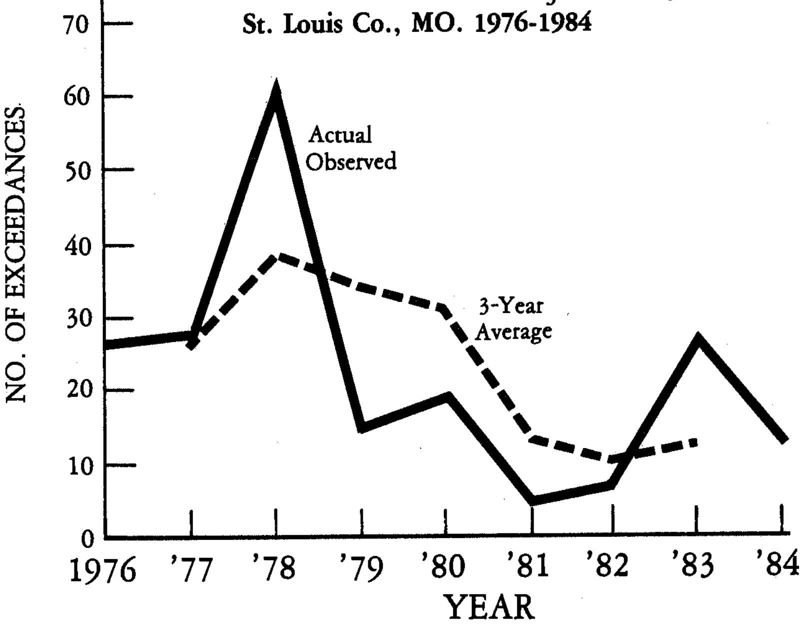

SALT LAKE CITY, UT
FREQUENCY OF EXCEEDENCES
(Days Per Year)
100
80
60
40
20
0
> 0.12 PPM
> 0.16 PPM
1977
'78
'79
'80
'81
'82
'83
'84
YEAR

FIGURE 1-8

COMPARISON OF ACTUAL AND THREE-YEAR RUNNING AVERAGE TRENDS IN EXCEEDANCES OF O_3 NAAQS

St. Louis Co., MO. 1976-1984



Three-year running average data were used to smooth out the year-to-year effects of meteorology. For example, Figure 1-8 shows the comparison of the trend in actual observations of days per year above the O_3 NAAQS and the three-year running average for St. Louis, Mo. The smoothing effect is evident. The use of a three-year interval is consistent with EPA's basis for determining attainment or non-attainment of the NAAQS, while allowing for air quality variations from year-to-year due to the influence of weather.

Effects of Meteorology on O_3 Levels

The PSI and ozone-specific trends analysis conducted by both CEQ and EPA clearly show how year-to-year weather variations can affect the frequency of the exceedances of the ozone NAAQS or the PSI "unhealthful" index. High ozone levels occur during periods when the air mass over an urban area stagnates. Such stagnations are associated with large-scale weather patterns such as the "Bermuda High" that occurs several times per year off the East Coast. These cause stagnation conditions in cities throughout the East. The number of such weather patterns varies from year to year; in a similar fashion, the number of opportunities for high ozone days varies from year to year. Achivement of the ambient air quality standard, from a statistical point of view, is to demonstrate

that the standard is not exceeded more than once per year *on the average*. This is to say that you could go for one or more years with no exceedances, but observe, in very hot years, several exceedances of the 0.12 ppm O_3 standard. EPA has chosen to use a three-year period as the basis for determining compliance with the ambient O_3 standard, as well as for establishing the baseline for planning purposes. For example, there could be no exceedances of the standard in the first two years of three consecutive years and three exceedances in the third, and the EPA criteria would be met. The intent for the standard would also be met if there were four consecutive years of no exceedance and five exceedances occurred in the fifth year, and so forth. The probability of this scenario or ones with greater time spans of no exceedances become less and less likely. An analogy would be the prediction of the occurrence of 5-, 25-, or 100-year floods.

An inherent assumption in the standard-setting process is that these exceedances will not cause any adverse health effects because their associated O_3 levels are expected to be within the margin of safety built into the standard. For ozone, the health effects benchmark used by EPA in revising the O_3 health effects standard was 0.15 ppm.[4] Therefore, when the NAAQS is legally achieved, in those years in which the number of exceedances are greater than one, the concentration on these anomalous days would only be slightly above 0.12 ppm. Such O_3 levels are not in the range where one would expect to observe adverse health impacts on the susceptible population.

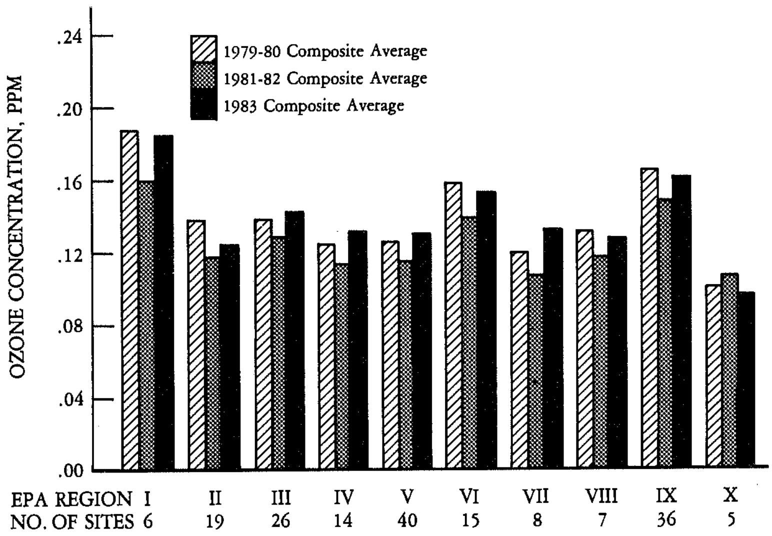
It is also important to point out that there are cold years as well as hot years with respect to the frequency of stagnation periods, as was the case in 1981 and 1982 in many areas of the nation. Therefore, in any attainment/non-attainment determination, the responsible regulatory agencies have to be cognizant of the fact that even though no exceedances occur in cold years, that particular area may or may not be in legal compliance with the standard. Take the previous case, in which there were no exceedances in two years, but three in the third. If four exceedances were to occur in the third year, the city would be in non-attainment based on EPA's criteria.

EPA has analyzed national data to determine the effect of the 1983 meteorological year. Figure 1–9 illustrates this phenomenon by comparing the average observation years 1979 and 1980 together, 1981 and 1982 together, and 1983 alone. EPA has suggested that the increase from 1982 to 1983 may be related to a slight increase in ***nationwide*** volatile organic compound (VOC) emissions.[5] It is the emissions of VOCs that are primarily responsible for ozone formation in urban areas. It remains to be seen whether or not the predicted nationwide increases in VOC emissions are having an impact on ambient ozone levels in ***individual*** urban areas.

CEQ independently has examined the meteorological effect by comparing the temperature profiles in several cities against long-term averages. These data for New York, Philadelphia, Washington, D.C., Boston, and St. Louis are shown in Figure 1–10. They confirm the air quality trends from the EPA data as well as CEQ's PSI data by showing above-average temperature conditions in 1979 and 1980, below-average temperature conditions in 1981 and 1982, and above-average temperatures for 1983. The CEQ data also include data for 1984, which

FIGURE 1-9

REGIONAL COMPARISON OF THE 1979-80, 1981-82, AND 1983 COMPOSITE AVERAGE OF THE SECOND-HIGHEST DAILY 1-HOUR OZONE CONCENTRATION



SOURCE: U. S. Environmental Protection Agency

show that the trend has dropped back to the norm or below. The CEQ trends data for ozone also reflect the return to the normal trend in 1984 in almost every city in the nation.

In conclusion, it must be recognized that weather affects observed air quality, particularly ozone levels, which are the most sensitive to meteorological conditions. The legal compliance with the NAAQS has a two-part goal: one is the achievement of the 0.12 ppm concentration on all days during the year except one; and the other is the limit of the one day-per-year frequency. Both of these parameters should be statistically determined from observed air quality and meteorological data.

Carbon Monoxide (CO)

Motor vehicles are the predominant source of carbon monoxide (CO) emissions in the United States. NAAQS for CO have been set for both 1-hour and 8-hour levels. The 1-hour standard specifies a level of 35 ppm not to be exceeded more than once per year, while the 8-hour standard specifies a level of 9 ppm not to be exceeded more than once per year. Because the 8-hour standard is generally more restrictive, this trend analysis focuses on the 8-hour data.

The 1975–83 trend for the second highest 8-hour CO value is shown in Figure 1–11a for data collected at 42 NAMS as reported by EPA. In that 9-year period the national composite average decreased by 33 percent. The median rate of improvement was approximately 5 percent per year, although there was little change between 1982 and 1983.

FIGURE 1-10
ANNUAL TEMPERATURE PROFILES VERSUS LONG-TERM AVERAGES

Days Above 90°F Per Year

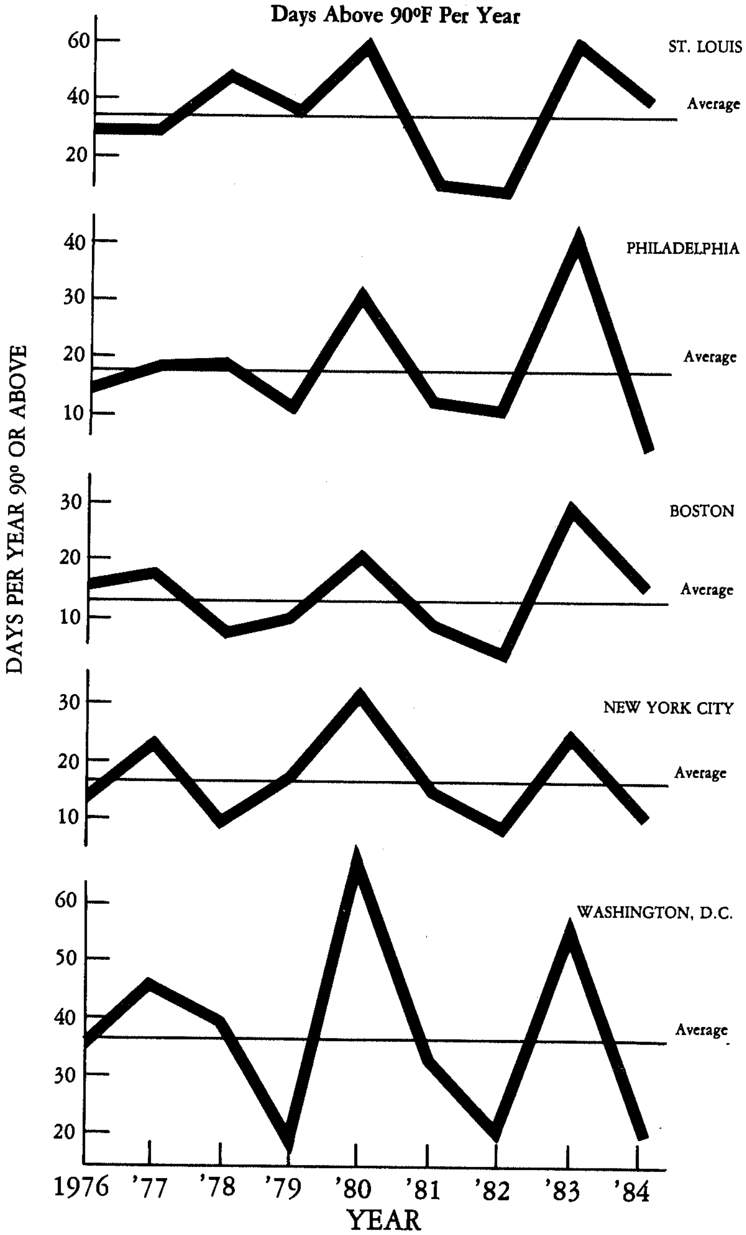


FIGURE 1-11a

NATIONAL TREND IN THE COMPOSITE AVERAGE OF THE SECOND HIGHEST NONOVERLAPPING 8-HOUR AVERAGE CARBON MONOXIDE CONCENTRATION AT NAMS SITES

1975 - 1983

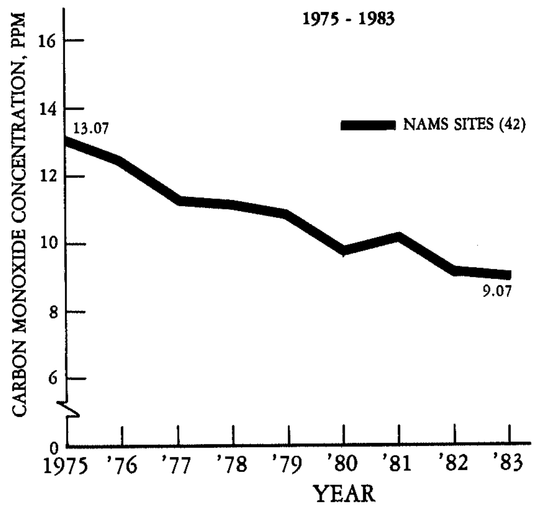
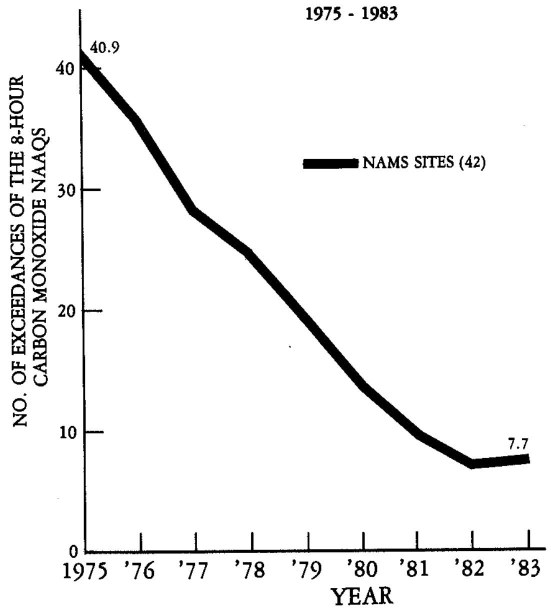


FIGURE 1-11b

NATIONAL TREND IN THE COMPOSITE AVERAGE OF THE ESTIMATED NUMBER OF EXCEEDANCES OF THE 8-HOUR CARBON MONOXIDE NAAQS AT NAMS SITES

1975 - 1983



SOURCE: U. S. Environmental Protection Agency

The composite average trend of the number of exceedances of the 8-hour CO NAAQS also declined sharply between 1975 and 1983, as shown in Figure 1–11b. This trend is consistent with the trend in ambient concentrations, although the decrease in exceedances is a more pronounced 81 percent decrease for the NAMS sites.

CEQ examined trends in CO air quality in 19 urban areas where the CO impacts are the greatest. Data from the most highly impacted county within each urban area were used for this analysis. It must be recognized that the worst-case CO impacts are usually associated with single monitors located adjacent to the most traffic-congested street within the metropolitan area. The CEQ analysis for 19 cities is shown in Figure 1–12. These data confirm EPA's findings but also illustrate how marginal the CO problem is with respect to attainment of the CO 8-hour NAAQS, except for a few cities.

Nitrogen Dioxide (NO_2)

Nitrogen dioxide (NO_2) is emitted by two main classes of sources: transportation vehicles and stationary fossil fuel combustors. Nationally, as shown in Figure 1–13, annual average NO_2 levels, as measured at 14 NAMS sites, have decreased over the 1975–1983 period, which is attributable to mobile source NO_x emission control.

All urban areas of the U.S., except Los Angeles, are in compliance with the NAAQS for NO_2. Most cities are more than 10–20 percent below the standard.

Sulfur Dioxide (SO_2)

Ambient sulfur dioxide (SO_2) levels result primarily from stationary source combustion of coal and oil and from nonferrous metal smelters. Trends in ambient SO_2 concentrations are derived from continuous monitoring instruments that measure as many as 8,760 hourly values per year. There are two primary NAAQS for SO_2: an annual arithmetic mean of 0.03 ppm and a 24-hour average of 0.14 ppm. The annual standard is not to be exceeded, while the 24-hour standard is not to be exceeded more than once per year.

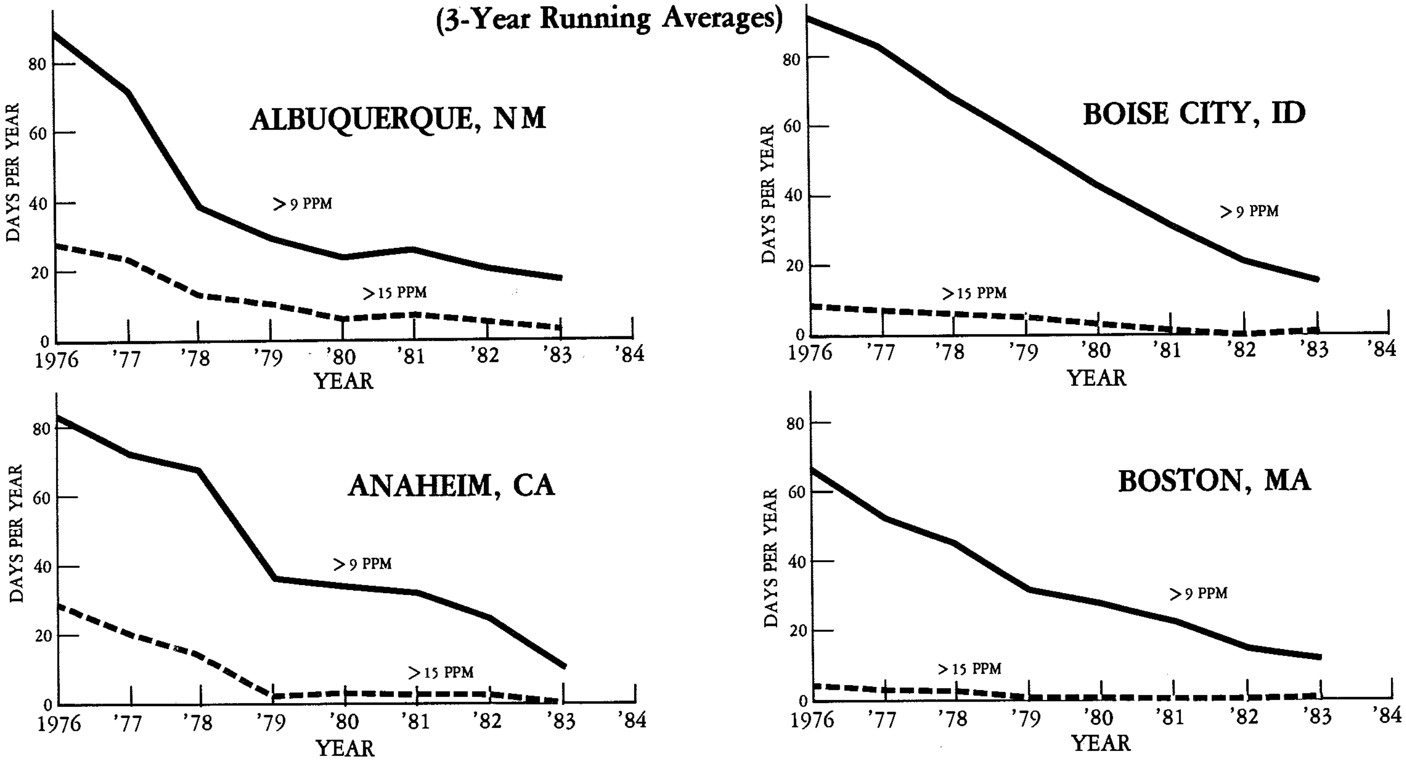
Trends in ambient SO_2 levels from 1975 to 1983 are graphically presented in Figures 1–14a and 1–14b. As the figures demonstrate, since 1976 a steady downward trend measured at the NAMS sites is evident in all cases. When the composite trends data are compared to the respective NAAQS, it is clear that the SO_2 problem, from the standpoint of public health impacts, has essentially been eliminated in the nation.

Total Suspended Particulates (TSP)

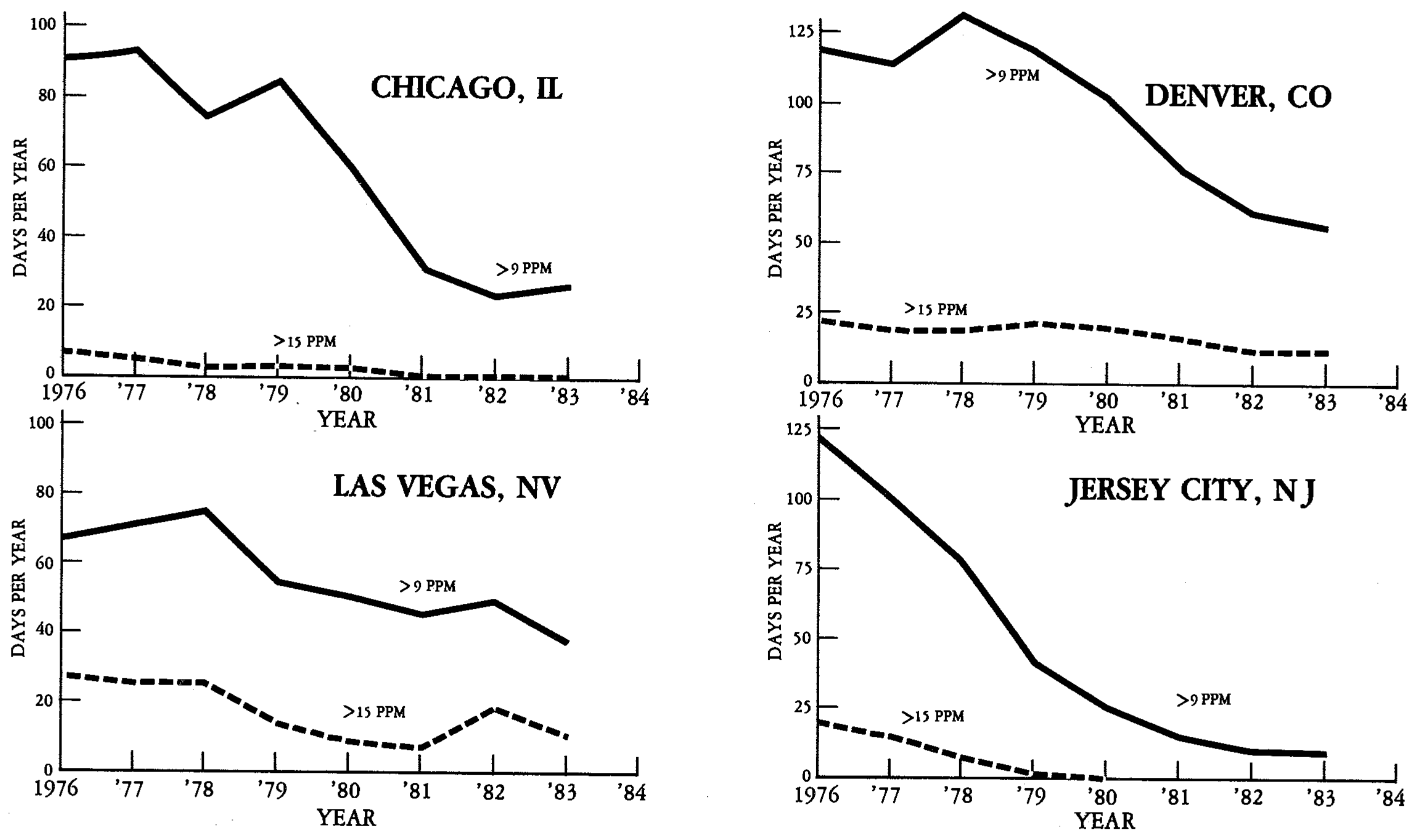
Particulate emissions have declined primarily because of reductions in industrial emissions in all urban areas. The marginal problems of total suspended particulates (TSP), which exist in some areas, are due primarily to fugitive dust emissions from some industrial sources, such as mineral processing facilities, as well as from non-industrial sources, such as resuspended roadway and agricultural dust. A pending change in the particulate standard will focus on

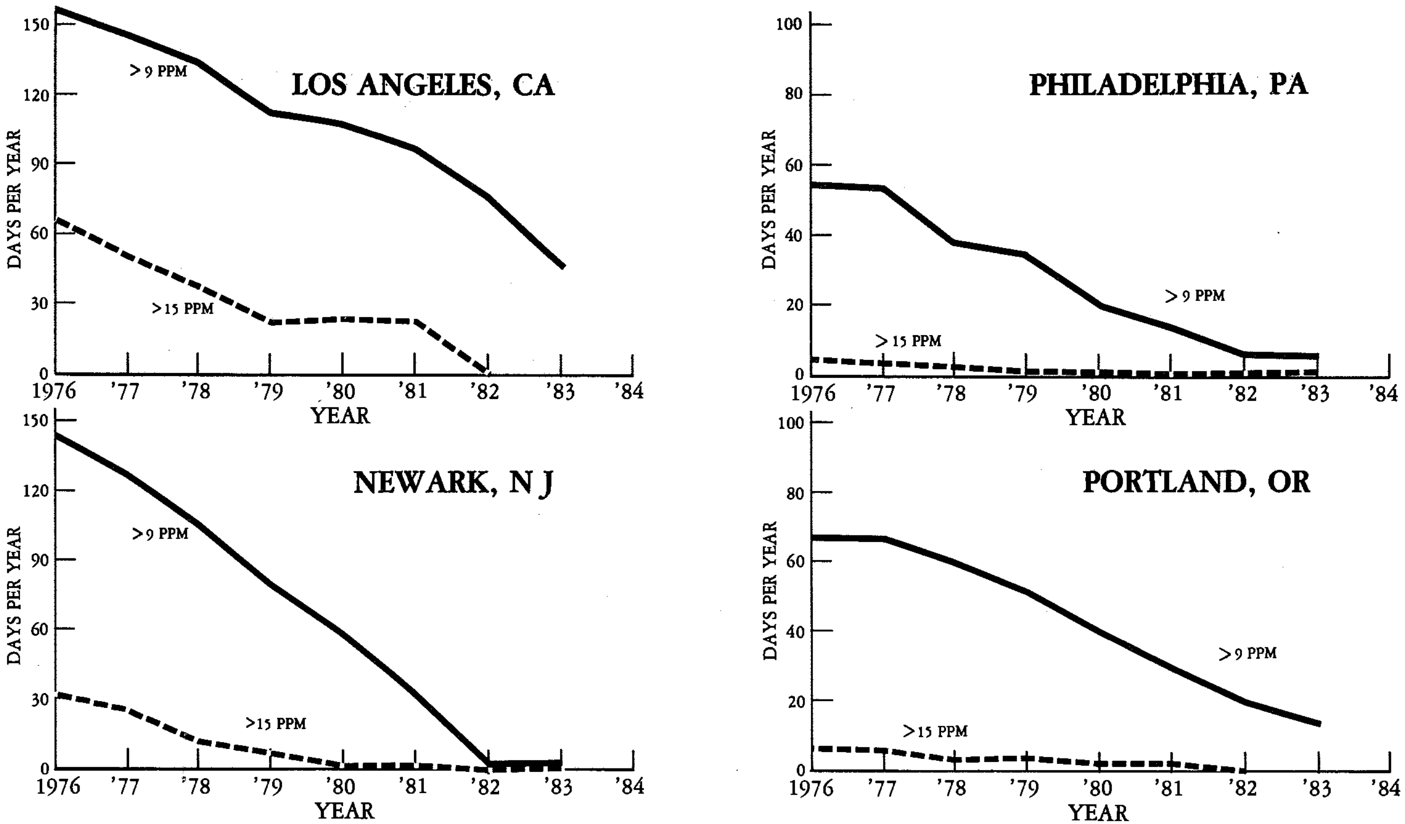
FIGURE 1-12

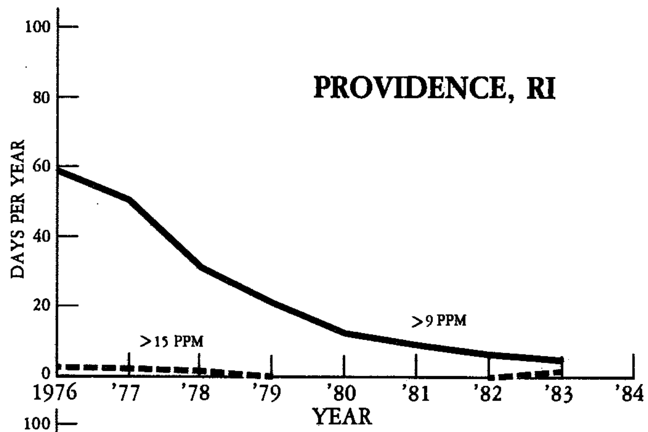
CO TRENDS BY SMSA
(3-Year Running Averages)

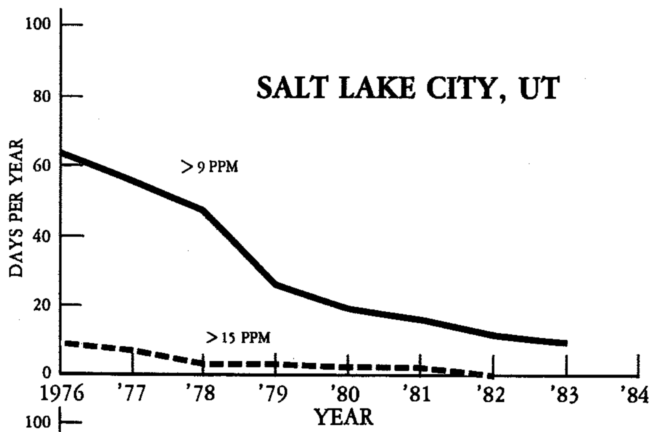


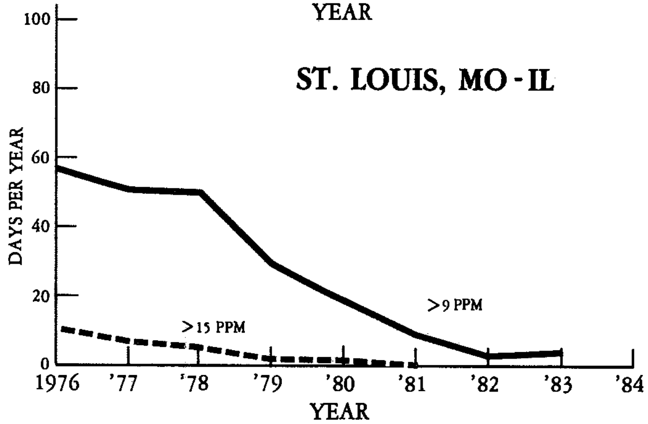
SOURCE: Roy F. Weston, National Air Quality Data System (based on U. S. EPA SAROAD data).

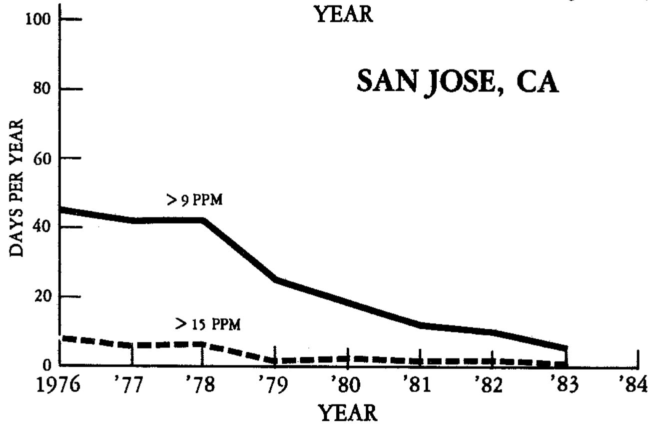

CHICAGO, IL
DAYS PER YEAR
100
80
60
40
20
0
>9 PPM
>15 PPM
1976 '77 '78 '79 '80 '81 '82 '83 '84
YEAR
DENVER, CO
DAYS PER YEAR
125
100
75
50
25
0
>9 PPM
>15 PPM
1976 '77 '78 '79 '80 '81 '82 '83 '84
YEAR
LAS VEGAS, NV
DAYS PER YEAR
100
80
60
40
20
0
>9 PPM
>15 PPM
1976 '77 '78 '79 '80 '81 '82 '83 '84
YEAR
JERSEY CITY, N J
DAYS PER YEAR
125
100
75
50
25
0
>9 PPM
>15 PPM
1976 '77 '78 '79 '80 '81 '82 '83 '84
YEAR

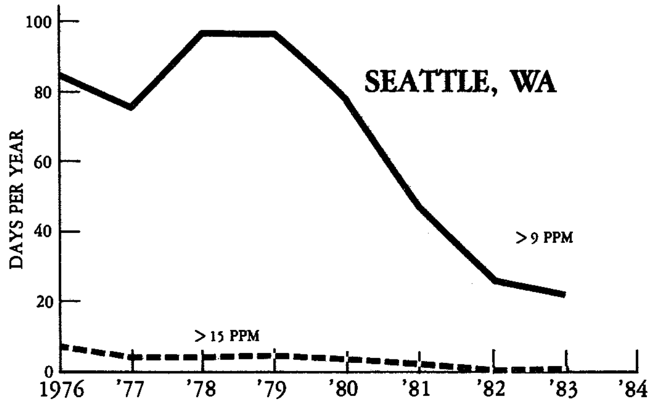

LOS ANGELES, CA
PHILADELPHIA, PA
NEWARK, N J
PORTLAND, OR
DAYS PER YEAR
YEAR
1976 '77 '78 '79 '80 '81 '82 '83 '84
>9 PPM
>15 PPM
0 30 60 90 120 150
0 20 40 60 80 100

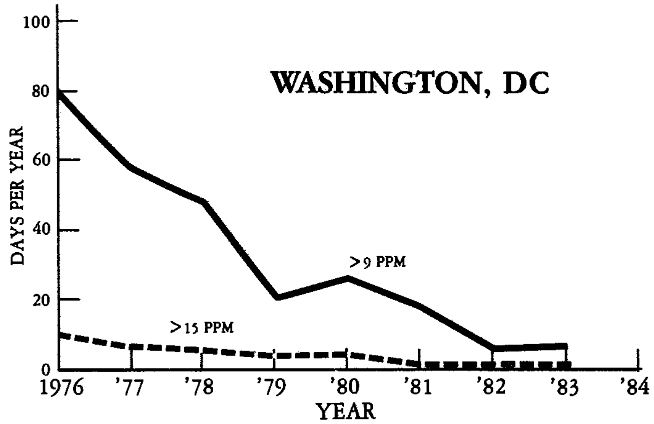

PROVIDENCE, RI
DAYS PER YEAR
100
80
60
40
20
0
>9 PPM
>15 PPM
1976
'77
'78
'79
'80
'81
'82
'83
'84
YEAR


SALT LAKE CITY, UT
DAYS PER YEAR
100
80
60
40
20
0
>9 PPM
>15 PPM
1976
'77
'78
'79
'80
'81
'82
'83
'84
YEAR


ST. LOUIS, MO - IL
DAYS PER YEAR
100
80
60
40
20
0
>9 PPM
>15 PPM
1976
'77
'78
'79
'80
'81
'82
'83
'84
YEAR


SAN JOSE, CA
DAYS PER YEAR
100
80
60
40
20
0
>9 PPM
>15 PPM
1976
'77
'78
'79
'80
'81
'82
'83
'84
YEAR


SEATTLE, WA
DAYS PER YEAR
100
80
60
40
20
0
> 9 PPM
> 15 PPM
1976 '77 '78 '79 '80 '81 '82 '83 '84
YEAR


WASHINGTON, DC
DAYS PER YEAR
100
80
60
40
20
0
> 9 PPM
> 15 PPM
1976 '77 '78 '79 '80 '81 '82 '83 '84
YEAR

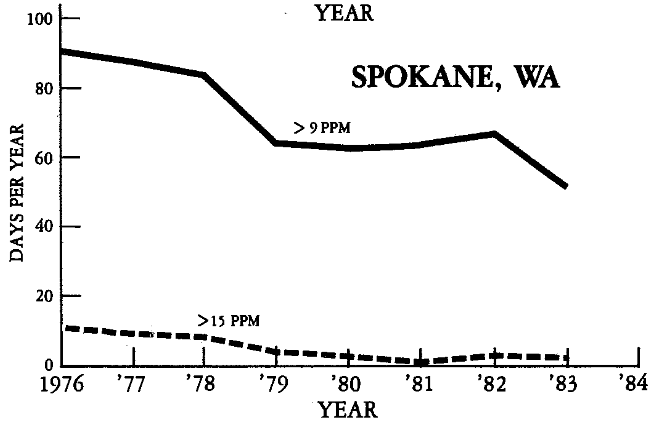
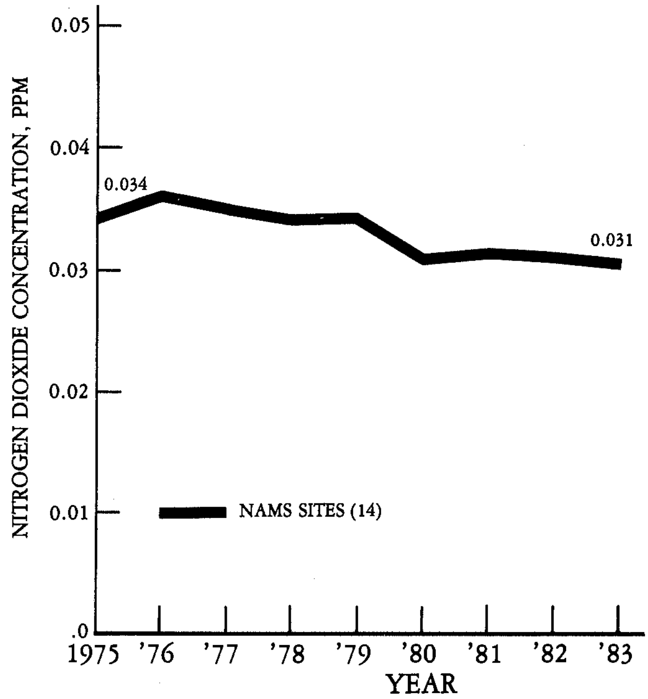

SPOKANE, WA
DAYS PER YEAR
100
80
60
40
20
0
> 9 PPM
> 15 PPM
1976 '77 '78 '79 '80 '81 '82 '83 '84
YEAR

FIGURE 1-13

NATIONAL TREND IN THE COMPOSITE AVERAGE OF NITROGEN DIOXIDE CONCENTRATION AT NAMS SITES
1975 - 1983



SOURCE: U. S. Environmental Protection Agency

the inhalable fraction of the total particle concentration. Therefore, the remaining TSP problems must be reevaluated in terms of the new standard when and if it is established because the contributing sources may differ because of their emissions characteristics. (See Figure 1–15.)

Lead (Pb)

Lead gasoline additives, nonferrous smelters, and battery plants are primary contributors to atmospheric lead (Pb) emissions. Transportation sources alone contribute about 80 percent of annual Pb emissions.

Prior to promulgation of the lead NAAQS in October 1978, EPA implemented a gasoline lead phase-down program, which resulted in lower ambient lead levels. First, in the early 1970s, regulations were issued to reduce the lead content in gasoline in order to protect the catalysts. The catalytic converter is an important part of the current technology for controlling auto emissions. Second, as part of EPA's program to protect human health, further reductions in lead in gasoline were mandated in 1975. The overall effect of these two control programs has been a major reduction in ambient lead levels.

Composite maximum quarterly averages for lead concentrations, as shown in Figure 1–16a, for 61 urban sites declined 67 percent between 1975 and 1983.

FIGURE 1-14 a

NATIONAL TREND IN THE ANNUAL AVERAGE SULFUR DIOXIDE CONCENTRATION AT NAMS SITES

1975 - 1983

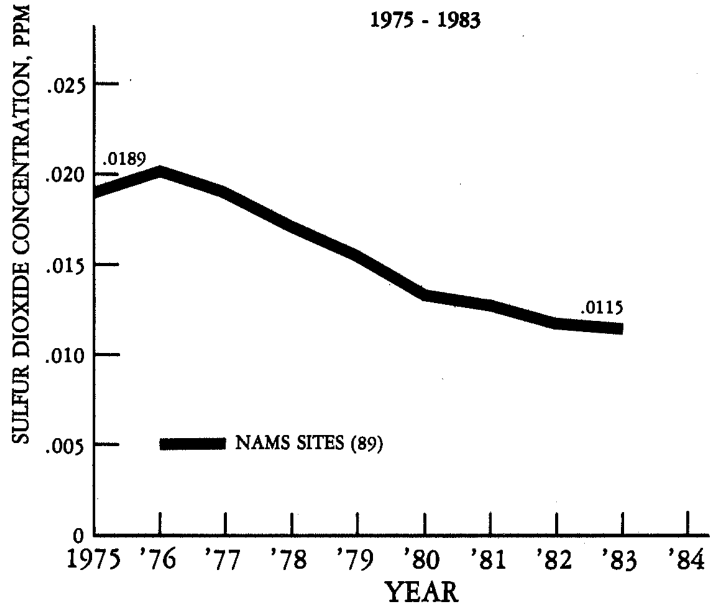
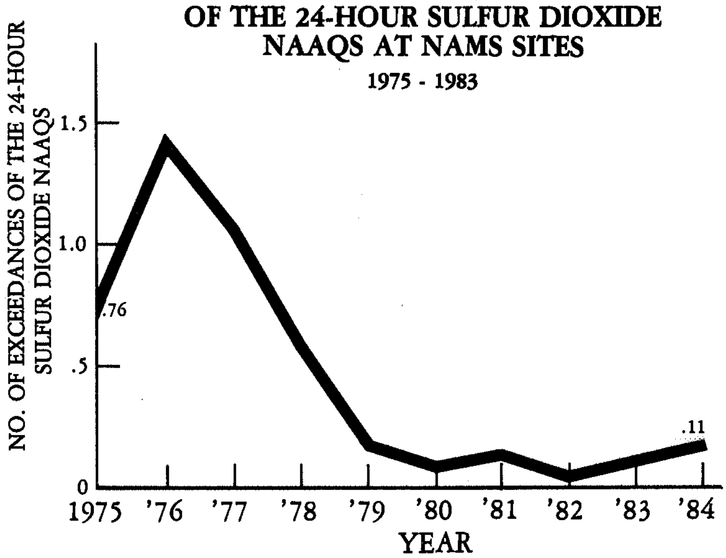


FIGURE 1-14b

NATIONAL TREND IN THE COMPOSITE AVERAGE OF THE ESTIMATED NUMBER OF EXCEEDANCES OF THE 24-HOUR SULFUR DIOXIDE NAAQS AT NAMS SITES

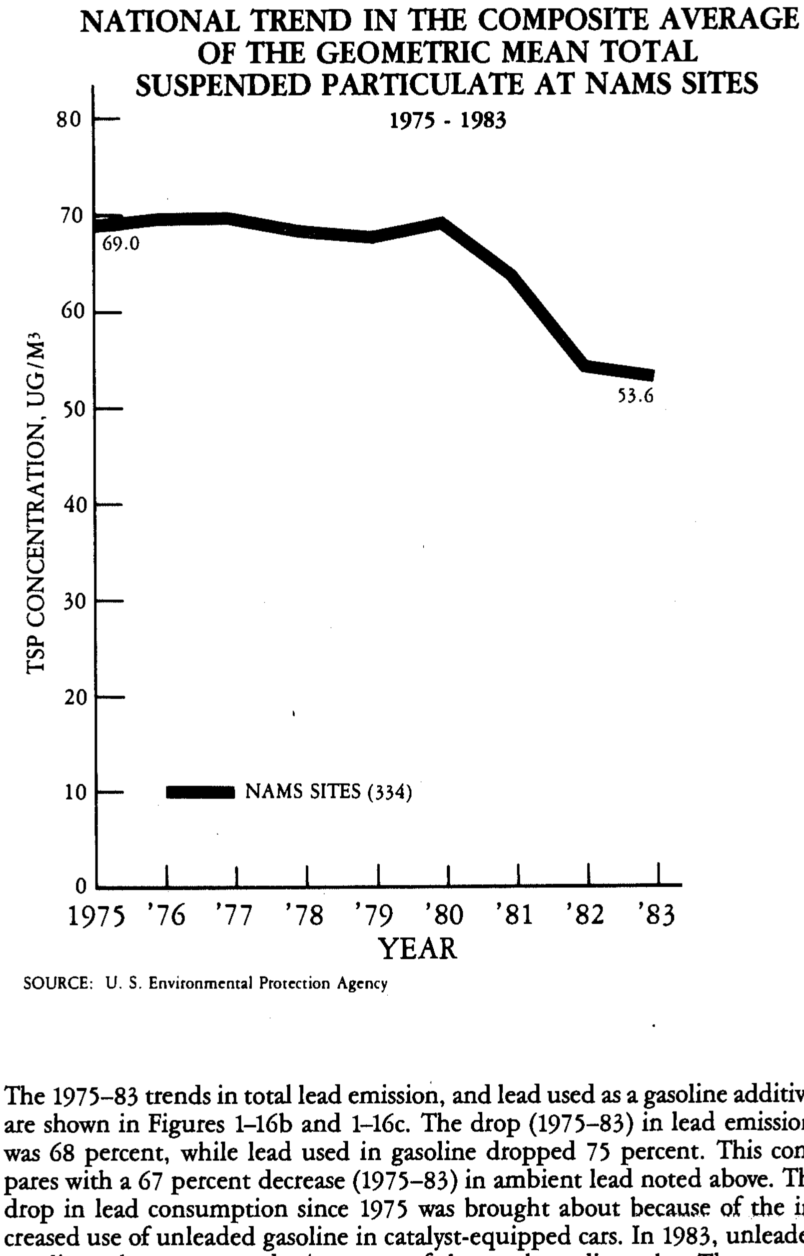
1975 - 1983



SOURCE: U. S. Environmental Protection Agency

P00000123083

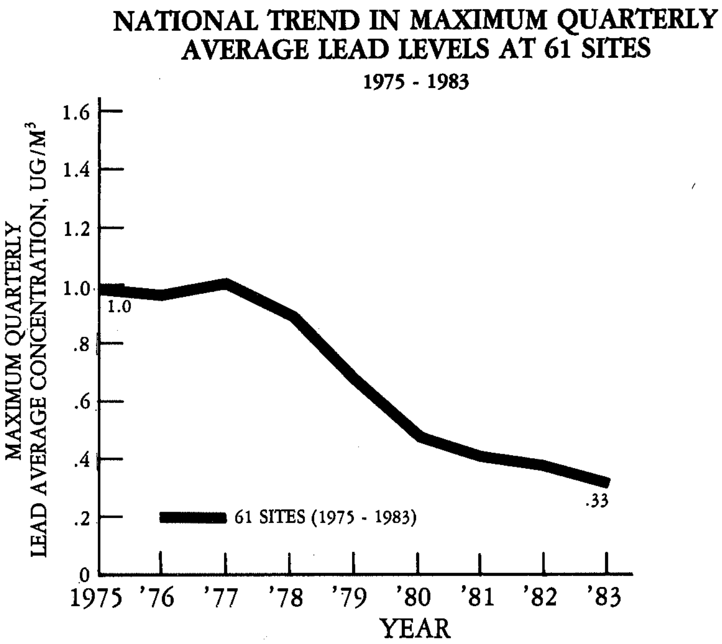
FIGURE 1-15



SOURCE: U. S. Environmental Protection Agency

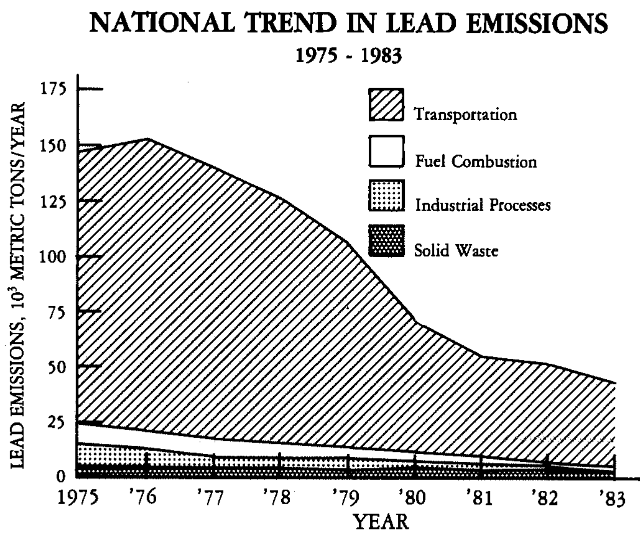
The 1975–83 trends in total lead emission, and lead used as a gasoline additive, are shown in Figures 1-16b and 1-16c. The drop (1975–83) in lead emissions was 68 percent, while lead used in gasoline dropped 75 percent. This compares with a 67 percent decrease (1975–83) in ambient lead noted above. The drop in lead consumption since 1975 was brought about because of the increased use of unleaded gasoline in catalyst-equipped cars. In 1983, unleaded gasoline sales represented 54 percent of the total gasoline sales. The general agreement among the trends in lead consumption, emissions, and ambient levels suggests that ambient urban Pb levels are responding to the drop in lead emissions.

FIGURE 1-16a



SOURCE: U. S. Environmental Protection Agency

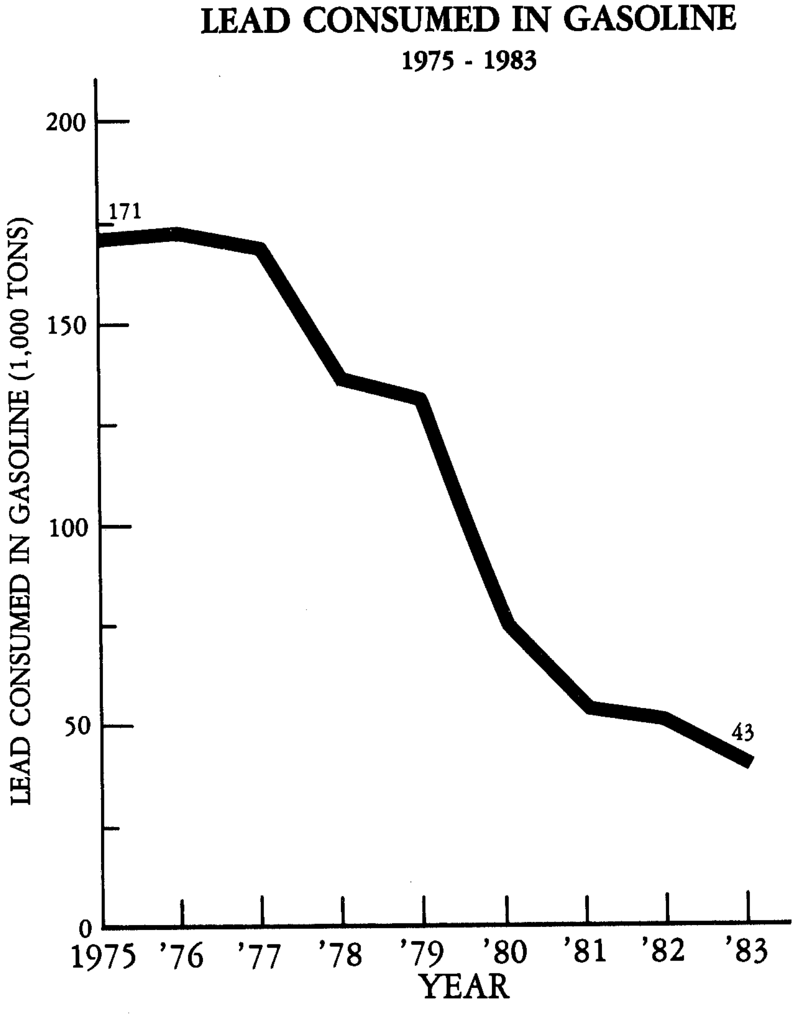
FIGURE 1- 16b



SOURCE: U. S. Environmental Protection Agency

P00000123085

FIGURE 1-16c



SOURCE: U. S. Environmental Protection Agency

Current Issues in Air Pollution Regulation

While the previous discussion assessed the overall status and current condition of the nation's air quality, there is also a need to look to the future — to review emerging issues and to discuss new information available and various approaches being considered to deal with remaining air pollution problems.

This section presents a 1984 study by the Environmental Protection Agency providing preliminary findings on the scope and extent of the air toxics problems;

an assessment of the "bubble" concept's ability to achieve cost-effective emissions controls without sacrificing air quality; a reevaluation of the efficacy of mandatory automobile inspection and maintenance programs; and an exploration of the costs and public health benefits of eliminating lead from gasoline.

These essays present important but by no means comprehensive selections of air quality issues that are currently being discussed and considered at the federal level. In several of these areas, more data and analyses are needed before recommending any final action; in others, recent research results may justify new or revised regulations.

HAZARDOUS AIR POLLUTANTS

In addition to the regulatory programs established to attain and maintain the National Ambient Air Quality Standards (NAAQS), the Clean Air Act contains several provisions for regulating toxic or hazardous air pollutants from stationary sources. Section 112, the primary mechanism for dealing with such pollutants, requires EPA to list pollutants "which may reasonably be anticipated to result in an increase in mortality or increase in serious irreversible, or incapacitating reversible, illness." Within one year of listing, EPA must promulgate emission regulations for source categories of the listed pollutant causing a significant risk to the public. These regulations, applicable to both new and existing sources, must be met within two years of promulgation.

Toxic Air Pollutants Listed or Regulated

To date, eight compounds have been listed under section 112, emission standards have been promulgated for five of these, and proposals are pending for two pollutants. The status of listings and regulations under section 112 is summarized in the first part of Table 1–3. Section 111 of the Act provides another mechanism for regulating non-criteria pollutants that may adversely affect public health or welfare. This mechanism involves EPA setting a new source performance standard (NSPS) for a pollutant not subject to the NAAQS or not listed under section 112. States are then required by section 111(d) to regulate existing sources of the same type covered by the NSPS. The only health-based pollutant regulated to date under section 111(d) is sulfuric acid mist, as shown in the lower part of Table 1–3.

Section 122 of the Act requires EPA to determine whether four specified pollutants (arsenic, radionuclides, cadmium, and polycyclic organic matter (POM)) endanger public health and, if so, to take appropriate action to regulate those pollutants. As shown in Table 1–4, arsenic and radionuclides have been listed under section 112. In August 1984, EPA published a decision not to regulate POM as a specified air pollutant.[6] This decision was based on a number of factors, including the great uncertainty as to the magnitude of the cancer risk to the public, the fact that many POM categories are being controlled under programs to attain and maintain the NAAQS for particulate matter, and difficulties in devising control programs for source categories not easily regulated (e.g., existing wood stoves, forest fires and agricultural burning). A decision on the final pollutant specified under section 122 — cadmium — is expected in 1985.

In addition to the POM decision, EPA published decisions on two other

Table 1-3.
Pollutants Listed/Regulated Under Sections 112 and 111 of the Clean Air Act

Pollutant	Listed		Proposal	Promulgated	Sources Regulated
	Date	Basis			
I. SECTION 112					
Mercury	3/31/71	Central Nervous System damage	12/71	4/06/73	Mercury smelters Chlor-alkali plants
			10/74	10/14/75	Sewage sludge incinerators
Beryllium	3/31/71	Berylliosis	12/71	4/06/73	Extraction plants Foundries Ceramics Rockets
Asbestos	3/31/71	Cancer	12/71	4/06/73	Asbestos mills Roadways Manufacturing processes
			10/74	10/14/75	Demolition
Vinyl chloride (VC)	12/24/75	Cancer	12/75	10/21/76	Ethylene dichloride producers VC producers VC polymers
Benzene	6/8/77	Leukemia	1/05/85	6/06/84	Fugitive emission sources
			6/16/84		Coke by-product plants
Radionuclides	12/27/79	Cancer	4/06/83	2/06/85	DOE facilities NRC-licensed facilities Elemental phosphorous plants

Table 1-3.—Continued
Pollutants Listed/Regulated Under Sections 112 and 111 of the Clean Air Act

Pollutant	Listed		Proposal	Promulgated	Sources Regulated
	Date	Basis			
Inorganic arsenic	6/05/80	Cancer	7/20/83	—	High arsenic copper smelters Low arsenic copper smelters
Coke oven emissions	9/18/84	Cancer	—	—	
II. SECTION 111					
Sulfuric acid	—	Lung damage	11/76	10/77	Sulfuric acid plants

potential air toxics in 1984. EPA published a decision not to regulate toluene as a specified air pollutant under the Clean Air Act on the basis that current information does not indicate a threat to public health at concentrations found in the ambient air.[7] Also, coke oven emissions were listed as a hazardous air pollutant under section 112 of the Clean Air Act.[8] Assessments containing information on the sources, emissions, public exposure, health effects, current controls, and possible control improvements were completed for most of the substances shown in the "Regulatory Options Analysis" column of Table 1-4. Notices concerning their regulation will be published in the Federal Register during 1985 and 1986.

Several actions involving the development of National Emission Standards for Hazardous Air Pollutants (NESHAPS) under section 112 were also taken in 1984. These actions relied much more heavily on principles of risk assessment and risk management than previous rulemakings under section 112. In June 1984, EPA promulgated regulations for benzene equipment leaks (fugitive emission sources)[9] and proposed regulations for benzene from coke oven by-product plants.[10] The Agency also withdrew three earlier proposals on maleic anhydride manufacturing, ethyl benzene/styrene plants, and benzene storage,[11] on the basis that the cancer risks to the public and the potential reduction in risk achievable with available control techniques did not warrant federal regulatory action for these source categories. For similar reasons, EPA also withdrew proposals for several source categories emitting radionuclides.[12] Advance notices of proposed rulemaking were published for radon-222 emissions, a class of radionuclides, from underground uranium mines and from licensed uranium mills. The Agency was subsequently found in contempt of court for the radionuclides withdrawals, and in February 1985, final regulations were published for three source categories.[13]

Table 1–4.

Toxic Air Pollutant Evaluation and Control Program[1]

Preliminary Health Screening	Detailed Assessment[2]	SAB Review[4]	Regulatory Options Analysis[5]	Regulatory Decisions[6]	NESHAPS Proposed	NESHAPS Promulgated
Copper	1,3 Butadiene	Chloroform	Acrylonitrile	Toluene (N)	Benzene	Mercury
Phenol	Dibenzofurans	Dioxins	Methyl chloroform	Beryllium (L)	Arsenic	Beryllium
Propylene		Nickel	Freon 113	Asbestos (L)	Arsenic (L)	Asbestos
Propylene oxide		Beryllium[3]	Carbon tetrachloride	Vinyl chloride (L)		Vinyl chloride
Acetaldehyde			Methylene chloride	Coke oven emissions (L)		Benzene
Acrolein			Manganese	Benzene (L)		Radionuclides
Hydrogen sulfide			Hexachlorocyclo pentadiene	Radionuclides (L)		
Chlorine & HCl			Gasoline vapors	POM (N)		
Ammonia			Chlorobenzenes	Mercury (L)		
Zinc oxide			Epichlorohydrin			
Styrene			Asbestos[3]			
			Vinylidene chloride			
			Ethylene dichloride			
			Chromium			
			Perchloroethylene			
			Trichloroethylene			
			Cadmium			
			Ethylene oxide			
			Chloroprene			
			Phosgene			

[1]As of 2/14/85.
[2]Health and exposure assessment. Not yet submitted to SAB.
[3]Reassessment of original health effects information.
[4]Submitted to SAB. Recommendations not yet received.
[5]Recommendations received from SAB or no SAB review planned. Analysis underway to determine need for regulation.
[6]L = listed under Section 112; N = decision not to regulate.

As part of the program for regulating benzene, EPA has been assessing the need to regulate sources in the gasoline marketing chain. This assessment was further spurred by data indicating that unleaded gasoline causes cancer in laboratory animals and should be considered a probable human carcinogen. An analysis of regulatory strategies for the gasoline marketing industry was published for public comment in August 1984.[14] The options considered were: (1) no additional control, (2) control of vehicle refueling (Stage II) in ozone non-attainment areas, (3) control of gasoline marketing emissions nationwide via (a) Stage II controls, (b) onboard vehicle controls, and/or (c) controls on bulk terminals and plants (Stage I). A decision on the appropriate regulatory option is expected in late 1985.

Establishment of National Air Toxics Information Clearinghouse

Also in 1984, substantial activities were undertaken to establish a National Air Toxics Information Clearinghouse in an effort to improve communication between EPA and state and local agencies, and among state and local agencies. The Clearinghouse is funded by EPA and is a cooperative effort between EPA and the State and Territorial Air Pollution Program Administrators and Association of Local Air Pollution Control Officials. The goal of the Clearinghouse is to disseminate knowledge about activities underway to solve toxic air pollutant problems and to reduce duplication of effort. Some of the kinds of information included in the Clearinghouse are: (1) regulatory program activities, including acceptable ambient limits; (2) source information, such as pollutants emitted and required control technology; and (3) source test and ambient monitoring methods in use. Automation of the data base and publication of the first report compiling all the information contained in the Clearinghouse were completed in the late summer of 1985.

Assessment of the Magnitude and Nature of the Air Toxics Problem

During 1984, EPA completed the most comprehensive assessment to date of the scope of the air toxics problem in this country.[15] However, the data available on air toxics significantly limited the scope of the analysis. For example, only cancer and direct inhalation were covered. It was not possible to consider quantitatively potential impacts caused by acute or chronic non-cancer effects; nor were the impact of indoor exposures, stratospheric contamination, and emissions from non-traditional sources such as hazardous waste disposal included. Conversely, many of the procedures and assumptions used were necessarily conservative. Carcinogenic potency (unit risk) values for the pollutants covered in the study assumed non-threshold effects, and generally only plausible upper-bound estimates were available for unit risk values. Some compounds were included for which carcinogenicity still is being debated.

These uncertainties make the analysis inappropriate for use in developing or supporting regulations, and this is clearly stated in the report. Nevertheless, the study is achieving its intended purpose, which is to describe the nature and possible magnitude of the air toxics problem, and to stimulate discussion on alternative national regulatory strategies and possible legislation.

The study utilized three new quantitative risk assessment analyses to estimate

the national annual cancer incidence and the individual lifetime risks associated with air toxics. Two of these analyses involved exposure estimates derived from estimates of emissions, meteorological dispersion, and population distribution. The NESHAPS study[16] included about 40 compounds and provided only national estimates of risk; a second exposure estimate, the 35 County Study,[17] was limited to 22 compounds, but provided more detail on the risk presented by source categories and on the city-to-city variability in risk. In a third analysis, ambient air quality data were used directly to estimate exposure and risk for about 15 compounds.[18]

Because of the large uncertainties inherent in quantitative risk assessment for environmental cancers, the results of this analysis must be interpreted with great care to avoid misuse of the study. With appropriate caveats that are detailed in the report, some of the more interesting findings presented in the study are:

1. Additive lifetime individual risks in urban areas due to simultaneous exposure to 10 to 15 pollutants ranged from one chance in 1000 to one chance in 10,000. These risks, which were calculated from monitoring data, did not appear to be related to specific point sources, but rather represented a portion of the total risks associated with the complex mixtures typical of urban ambient air.
2. Both "point" and "area" sources appear to contribute significantly to the air toxics problem. Large point sources are associated with many high individual risks; area sources appear to be responsible for the majority of aggregate incidence.
3. For the pollutants and sources studied and using unit risks that are plausible upper-bound values, annual national cancer incidence ranged from 1600 to 2000 per year. To place this figure in perspective, it should be noted that approximately 440,000 deaths from cancer occur annually in the United States from all causes.
4. The air toxics problem appears to be very diverse with no source category or specific pollutant appearing to dominate the analysis. Organic particulates (called Products of Incomplete Combustion and represented by benzo-a-pyrene in the study) accounted for about 45 percent of the incidence; volatile organics, about 30 percent; and metals, about 25 percent.
5. For those cities with sufficient data for analysis, large city-to-city and neighborhood-to-neighborhood variation in pollutant levels and sources was found. However, our current data base is inadequate to characterize most local air toxics problems.
6. Criteria pollutant control programs (i.e., those related to pollutants covered by National Ambient Air Quality Standards) appear to have reduced air toxics risks over the past decade more than have programs for specific toxic compounds. This seems reasonable considering the widespread sources of air toxics, the multi-pollutant nature of the problem, and the relative intensity of regulatory programs for criteria pollutants, especially those for ozone and particulate matter.

Strategic Implications

The findings of the study on the magnitude and nature of the problem suggest the need for a review of EPA's current program for hazardous air pollutants

and an examination of potential new strategies. To facilitate this, the Administrator has established within EPA an Air Toxics Group to follow up on the assessment report. The group's activities include presentation and discussion of the findings of the study with a wide variety of affected organizations, including state and local air agencies, environmental and public health groups, industries that produce and use potentially toxic compounds, and other governmental agencies, including Congressional staff.

Meetings with these groups include discussions of alternative national strategies and possible legislative changes. In addition, EPA has given a grant to the Center for Negotiation and Public Policy to promote more formally the exchange of opinions and information on air toxics strategies between diverse groups.

To aid in evaluating strategic options, EPA also has initiated several follow-on analyses. These include:

- The controllability of the pollutants identified as associated with the highest incidence. This analysis will assess available technology and control costs.
- The impact on annual cancer incidence of pollution control achieved by 1995 through the implementation of regulatory programs for criteria pollutants.
- The impact on cancer incidence of the current air toxics programs through 1995.
- The potential of including in a regulatory strategy non-cancer health implications, including effects on reproduction, mutagenesis, and acute effects.

The initial assessment report, the discussions, and the additional analyses were all being utilized in developing the comprehensive national air toxics strategy which was released by EPA in June 1985.

NEW SOURCE PERFORMANCE STANDARDS AND THE "BUBBLE" CONCEPT

Control of stationary sources of air pollution has traditionally been implemented on a stack-by-stack or an equipment-by-equipment basis. Thus, a single plant containing several stacks or pieces of equipment emitting air pollutants is generally subject to numerous individual rules or emission limitations. Because the cost of controlling pollutants varies with the process (or equipment), volume of exhaust gas, pollutant concentration and composition, temperature, and so on, it is generally cheaper and easier to reduce a ton of pollutant at one stack (or equipment) than at another within the same plant. This variation in control costs becomes even more pronounced across different plants and types of plants. For example, certain volatile organic compound (VOC) controls can virtually pay for themselves at some plants, while their cost at other plants could run into hundreds of dollars per ton.

Because of the variation in control costs, it would be logical to control some stacks or pieces of equipment within a plant, or even some plants, more than others. The precise level of control at each stack within a plant can always be estimated if one wants to optimize costs (given cumulative emissions) or emissions (given total cost).

The "bubble" concept was devised to achieve just such optimization. Under

this concept, a number of stacks or even plants could be grouped together and treated as if they were all enclosed by a large bubble. Thus, instead of being concerned with emissions from each stack, one could deal with the cumulative emissions from that bubble. This approach allows firms to undercontrol those stacks where control is expensive while overcontrolling at other stacks where control is cheap — as long as the total emissions are not increased by comparison with the traditional (equipment-by-equipment) approach. The overcontrolled source is considered to have generated surplus emission reductions or an emission reduction credit (ERC), which can be used by the undercontrolled source. The bubble concept, therefore, relies on "emissions trading."

In addition to providing a bigger bang for the same buck, or the same bang for a smaller buck, bubbles can also provide other benefits, such as the following:

- The greater opportunity for firms to benefit from devising more cost-effective solutions to emissions reduction encourages them to pursue more actively technological and process innovations for reducing air pollution, which in turn help to advance the state-of-the-art of pollution control and/or technology transfer from industry to industry.
- The bubble provides a mechanism for firms to devise more cost-effective solutions or to fine-tune broad solutions to air pollution than can be obtained via government-imposed regulations. This is true even where such regulations are designed to optimize control costs given emissions or air quality targets, because broad solutions devised by a regulatory agency must of necessity rely on generalized "national" models, which usually cannot take individual plant factors into consideration.
- By providing firms with greater flexibility, the bubble concept makes them part of the solution rather than the problem, which engenders greater cooperation between the regulators and the regulated.

However, in spite of these advantages, bubbles can be environmentally unsound unless the requisite environmental safeguards are built into them to ensure that emissions reductions are indeed surplus, permanent, and enforceable. Moreover, both emissions increases and decreases must be quantifiable to establish overall environmental and emissions equivalence.

Major Milestones Leading Up to NSPS Bubbles

EPA's first major attempt to employ the bubble concept, in fact, came in the context of New Source Performance Standards (NSPS) when, in 1975, it allowed a new emitting "facility" at an existing plant to avoid being subject to NSPS if existing facilities at that plant reduced emissions sufficiently to compensate for the new emissions.[19] This attempt was ruled illegal by the D.C. Court of Appeals in 1978. In that decision the Court reasoned that, under the Clean Air Act, applicability of NSPS was to be determined on the basis of an individual facility and not on the *combination* of facilities (*ASARCo, Inc. v. EPA*).[20] Moreover, the Court noted, such a bubble would postpone cleanup of existing sources.

However, before the *ASARCo* suit was decided, several important events occurred that legitimized various aspects of emissions trading schemes. In 1975, the original deadline for attaining NAAQS passed, with several areas unable to show attainment. This raised the question whether any new emissions could

be added in such areas due to construction or modification of new sources or facilities. To deal with this, EPA published its "offset" policy in 1976, which allowed such construction or modification as long as any increases in emissions were more than offset by emissions reductions elsewhere and, among other requirements, these reductions resulted in equivalent ambient impacts. The 1977 Clean Air Act Amendments incorporated, with certain changes, EPA's offset policy.

The most important aspect of the offset policy was that it legitimized the notion that certain emissions reductions would be surplus. Moreover, many of the solutions devised to the technical and legal problems inherent to the offset policy could be and have been used for other emissions trading schemes. These problems include:

- Identifying surplus emission reductions;
- Quantifying and comparing emissions for widely differing source categories and types of emissions limits;
- Ensuring enforceability at two facilities owned by different firms;
- Ensuring environmental equivalence when offsetting reductions are obtained from facilities that are not co-located.

EPA's next major emissions trading effort was articulation of the bubble policy for *existing* sources in 1979.[21] This was subsequently revised in 1982 and incorporated into the "Interim Emissions Trading Policy Statement" (IETPS).[22] The IETPS deals with bubbles, offsets, "netting,"[23] and banking of emission reduction credits.[24]

As of October 1984, EPA had directly approved 37 bubbles under the IETPS and proposed to approve nine more, with savings estimated at over $200 million over the traditional approach. Of these 46 bubbles, approximately 60 percent would produce emissions reductions beyond those required under the traditional approach. States, under their authority, have also approved about 25 bubbles. Cost savings resulting from these state-approved bubbles and about 125 more currently under development or review at various governmental agencies have been estimated at $500 million.[25]

While apparently the present bubble policy has been relatively successful, among its many limitations is that sources subject to New Source Performance Standards (NSPS) have so far been precluded from using it.

New Source Performance Standards (NSPS)

The 1970 Clean Air Act authorized the establishment of performance standards for new stationary sources or existing sources, if they were modified in ways that increased air emissions. The major reasons for instituting these NSPS were that: (1) emissions can generally be reduced more cheaply and easily if control and/or low emissions potential is designed into the system initially rather than being retrofitted; (2) nationwide standards were necessary to avoid "environmental blackmail" by firms that might otherwise threaten to move to states willing to become "polluter havens"; (3) the government should "force" technology and create markets for new pollution control technology; and (4) stringent standards for new sources would provide room for greater economic growth by reducing the likelihood that ambient air quality would reach the National Ambient Air Quality Standards (NAAQS).

Since 1971, EPA has promulgated NSPS for about 50 of the more polluting stationary source categories. The regulation for each source category, contained in a subpart of the overall NSPS regulation (40 CFR 60), often addresses major emission points or processes and pollutants typical of that category.

How NSPS Are Established

EPA's methodology for setting NSPS for any source category involves detailed engineering and economic studies. The engineering studies consist of analyses of polluting processes and equipment used by sources in that category, surveys of the state-of-the-art of control methods, field data on the effectiveness of such methods, and how many and for how long sources have used the various control options. Based on these analyses, EPA identifies that option (or options) that it considers to be "best demonstrated technology" (BDT).

The ultimate standards are based on the BDT and judgments involving its affordability by sources, cost-effectiveness based on "model" plants, impact on air emissions, and other non-air environmental and energy impacts.

Windfall Credits and How NSPS Is Selected

To appreciate the debate over NSPS bubbles, one must understand how BDT and NSPS are selected.

Selection of BDT generally involves examination of emissions test data from well-maintained existing sources from the pertinent source category. Depending on how different control technologies fare against each other and the prevailing use and length of experience sources in that category have with each technology, one or more BDTs may be selected. Occasionally, a particular technology that may have been successfully used for a similar application but for a different source category may be selected as BDT, that is, BDT may be based upon "technology transfer."

Once the BDT has been identified, the performance standard is almost invariably set at a level such that a source installing BDT is indeed able to meet NSPS even after accounting for changes in raw materials, fuels, and normal equipment deterioration, while a source installing something less than BDT is likely not to meet the standard. Because of this, the emissions standard (NSPS) is generally set at the higher end of the levels indicated by emissions tests on that BDT, that is, the standard is usually determined by what some have called "the-worst-of-the-best."

A notable exception to this approach was the 90 percent SO_2 scrubber control requirement for the revised NSPS for utility boilers. The 90 percent continuous control requirement was much better than the norm at the time the data for that NSPS were gathered. Another exception, but in the opposite direction, was the carbon monoxide NSPS for fluid catalytic cracking units at petroleum refineries, for which NSPS was specified at an emissions level much higher than that achievable by the BDT to allow usage of a new, more cost-effective technology, which nevertheless would result in higher emissions.

Because of the "worst-of-the-best" approach towards selecting NSPS, a facility installing BDT will almost automatically perform better than the allowable NSPS. It has been argued, therefore, that this could result in a "windfall" of surplus emissions reduction credits, especially if these credits are calculated

using the allowable-NSPS level as the baseline. Such windfall credits, if used to forego or reduce controls elsewhere, could increase "real" emissions over and above what may occur with the traditional approach (facility-by-facility). This potential for windfall credits complicates any calculations for estimating surplus emissions reductions for NSPS bubbles.

NSPS Bubbles

As noted earlier, EPA's first attempt to use bubbles for NSPS was unsuccessful. However, while the *ASARCo* decision ruled that applicability of NSPS could not be determined by "bubbling" new and existing facilities together, it did not preclude EPA from defining "facility" much more broadly than had been its practice heretofore, nor did it disallow bubbles to be formed purely from facilities subject to NSPS.

NSPS for the Manufacture of Pressure Sensitive Tapes and Labels: Broad Definition of "Facility"

In October 1983, EPA promulgated the NSPS for the manufacture of pressure sensitive tapes and labels (PSTL) and incorporated a broad "facility" definition that included an entire production line.[26] Thus, all the coating operations in a line, with each operation consisting of a coating application (by a coating head), followed by a drying oven, would be lumped together as a single facility. Under such a bubble, a firm could choose to control that coating operation with the cheapest emission reduction. It could, for example, use coatings with little or no VOC for some operations and use this fact to forego controls at other operations. Such flexibility would encourage development and usage of inherently less polluting coatings.

It has been estimated that such a bubble could also save a firm $500,000 for each new coating line.

The "Compliance" Bubble

Another formulation of a NSPS bubble, deemed by EPA to be legal, involves only facilities subject to NSPS, such that one facility could be overcontrolled while another undercontrolled as long as the total emissions from both facilities do not exceed the emissions resulting from the traditional approach, that is, if the NSPS were applied to each separately. The jargon for such a construct is the "compliance" bubble — so called because while NSPS are applicable to both facilities, the bubble is merely a convenient method for both to comply as a package.

The Central Illinois Public Service (CIPS) NSPS Compliance Bubble

On January 25, 1985, EPA proposed approval of the first NSPS compliance bubble in response to a proposal from CIPS first made in 1981.[27] The CIPS compliance bubble involves two identical utility boilers (Units I and II), both subject to the original 1971 boiler NSPS (40 CFR 60, Subpart D), which required an SO_2 emission limitation of 1.2 pounds (lbs.) per million BTU (MMBTU) heat input without specifying that scrubbing must be utilized to comply with that limitation.

Currently Unit I uses high sulfur coal controlled by a double alkali flue gas desulfurizer capable of substantial overcontrol. Unit II uses low sulfur coal capable of 1.2 lbs. SO_2 per MMBTU. Under the proposed bubble, Unit II would use locally-available medium sulfur coal with emissions of 1.8 lbs. SO_2/MMBTU, and any excess emissions at this unit would be offset by additional reductions at Unit I.

Several safeguards have been incorporated into this proposal:

- To eliminate any "windfall" credits, a combined SO_2 emission limitation of 1.1 (rather than 1.2) lbs./MMBTU would be the new limit.
- Compliance with the combined SO_2 limit is proposed to be measured using continuous emission monitors on stacks for both units and weighting the emissions from each according to their individual heat inputs.
- If either unit is shut down, the compliance bubble will be dissolved and the original 1.2 lbs./MMBTU limit reinstated.

Finally, the proposal contains malfunction requirements that are considerably more stringent than those required under the current (pre-bubble) NSPS. For example, normally all emissions during a scrubber malfunction may be excluded from counting towards the compliance calculations. Under the bubble proposal, however, only emissions during the first 250 hours of malfunctions in any calendar year may be so excluded. Another more stringent feature of the proposal is that if a scrubber malfunction extends beyond 16 hours, then coal from Unit II, which is cleaner, would be fed to Unit I, which would otherwise operate with much dirtier coal.

Impacts of the Proposed CIPS Bubble

If the bubble were to be denied, CIPS would either have to import low sulfur Western coal or install a scrubber for Unit II. The impacts of the bubble over either of these options, which are consistent with the traditional approach, are given below:

- Because of the lower emission limits and the more stringent malfunction provision, EPA estimates *annual* SO_2 emission reductions of about 3100 tons due to the bubble even after accounting for the "windfall."
- CIPS estimates an *annual* cost saving of $22 million over the low sulfur Western coal option.
- Unit II's requirements for medium sulfur coal would benefit the local coal industry in Illinois and Indiana by creating a demand for otherwise unmarketable coals.
- If scrubbing were the option selected for Unit II in the absence of a bubble, this would result in higher energy usage and possible higher NO_x emissions.
- The low sulfur Western coal option in lieu of the bubble would probably result in higher particulate matter (PM) emissions since the efficiency of precipitators (used for PM control) usually drops with reduced sulfur content.

Prognostications on NSPS Bubbles

While final action on the CIPS compliance bubble is not expected before late 1985, the magnitude of potential savings associated with this bubble proposal

indicates that wide use of NSPS compliance bubbles could result in annual savings of several millions of dollars without compromising environmental quality. However, the CIPS experience also indicates that processing such bubbles can be very resource-intensive and time-consuming. EPA is currently considering whether it should articulate a general NSPS compliance bubble policy in a *Federal Register* notice to lay out whether it will entertain any NSPS bubble applications — and if it does, what general criteria a specific application should meet to be approvable. Such a notice, it is presumed, will draw heavily on the CIPS experience as well as the several years of experience regulatory agencies have had with other emissions trading schemes.

STATE INSPECTION AND MAINTENANCE PROGRAMS

Mandatory automobile inspection and maintenance (I/M) is one of the most controversial regulatory strategies currently being implemented. In terms of its impact on the general public, I/M has become a major environmental program. By the end of 1985, about 46 million vehicles, 29 percent of the U.S. fleet, will be subject to emissions inspection annually or biennially. Inspection costs alone will total about one-third of a billion dollars per year. For about two-thirds of inspections, the I/M program requires at least one special trip, and possibly two. (For the rest, the I/M test is combined with an existing safety check, so an additional trip is rarely needed.)

Authorization of I/M Programs and Early Design

The authorization for I/M programs was established by the Clean Air Act Amendments of 1977. The I/M provision was initially intended to enable states to implement such programs where needed to meet the Act's mandated photochemical oxidant/ozone (O_3) and carbon monoxide (CO) National Ambient Air Quality Standard (NAAQS) attainment deadlines. At the time, the O_3 standard was more stringent than it is now (0.08 ppm versus the current 0.12 ppm). In January 1979, EPA promulgated a revision to the NAAQS for photochemical oxidants, basing the new standard on ozone. (Photochemical oxidants are approximately 90 percent ozone). The difference between the two ambient O_3 standards translates into a 20 to 30 percent difference in the control requirement for volatile organic compounds (VOC) in those urban areas with severe O_3 problems. The initial CO standard is still in effect; however, it is currently under review.

The Clean Air Act required that states failing to attain the ozone standard by 1982 and requesting an extension to 1987 must implement an I/M program. The legislative history makes it clear that each state had the authority to define a "reasonable" I/M program, based on its individual VOC and CO control requirements. Alternatively, EPA was required to establish what the Agency deemed to be a reasonable I/M program for any state requiring an extension but failing to enact its own program. The resistance to such programs in many states has forced EPA to assume greater responsibility.

In the late 1970s, EPA's definition of a "reasonable" I/M program was rather rigid. EPA's I/M approach was designed to fail 20 to 30 percent of all cars inspected and allowed little latitude in inspection methods. For example, EPA's

plans required tailpipe measurement of emissions, and would not accept visual inspection alone for tampering. Few, if any, EPA-designed programs were tailored to the specific air quality needs of the urban areas involved. As time passed, however, EPA began to allow more flexibility in the design of programs, to better match local needs. It also must be recognized that in 1977, when I/M programs were mandated, no one knew the reliability of catalytic emission control systems. Would such systems gradually deteriorate through normal use? Would they fail mechanically? Or would drivers deliberately circumvent the systems? The target date for maximizing the emission reductions from the automobile population through I/M was also not clearly established.

Without the knowledge of these and other factors, EPA found it extremely difficult to design cost-effective programs to meet the intent of the federal legislation. EPA felt compelled to design a uniform program based on readily available data. These data related mainly to non-catalyst control technology, although they were adjusted for that data available for 1975 to 1978 model-year cars equipped with catalytic converters. However, that early technology was slated for replacement by a radically different catalyst technology — three-way catalysts — by 1980. Therefore, I/M programs had to be designed to reduce in-use emissions from successive "generations" of cars using three separate emission control technologies.

Analysis of I/M Progress

The effectiveness of an I/M program with respect to each of these three families of vehicles (pre-catalyst, early catalyst, and three-way catalyst) is quite different. Net effectiveness must account for: (1) the number of vehicles in each class that are failing inspection; (2) the extent of emissions reduction achieved by maintenance; and (3) the period for which the "corrected" vehicle maintains its new emission profile. The I/M program design must also consider such factors as the number of vehicles in each class, the mileages they travel, the meteorology of the design region, and the extent to which all these and the earlier information are expected to change as economic and demographic situations change. For example, the economic recovery in the early years of the Reagan Administration encouraged new car purchases and hence an acceleration of the trend to less polluting vehicles. A 20–30 percent failure rate for pre-catalyst cars has been observed in most existing I/M programs, while EPA finds the current failure rates, based on the tailpipe emissions measurement, for 1981 and newer model-year cars to range from less than one percent to five percent.[28]

Table 1–5 shows a listing of all current I/M programs, along with specific information, for example, the date the program was started. Only five programs test for the presence of leaded fuel, while all but three programs require tailpipe measurements.

As time passes there is a significant shift in the age of the "population" of in-use vehicles and therefore in the relative emission contributions of newer versus older vehicles. Thus, even though the inspection of a pre-1975 vehicle may show high failure rates (and thus credited with significant per-vehicle emission reductions when tuned up again) the contribution of this family of vehicles to the *total* mobile source emissions inventory in an urban area diminishes rapidly with fleet modernization.

Table 1-5.
Inspection/Maintenance Program Summary

EPA Region	State	City (SMSA)	No. of Counties	Program Started	Model Years Inspected	Emissions Test	Lead Test
I	CT	Statewide	–	1/83	1968+	Yes	No
	MA	Statewide	–	4/83	last 15	Yes	No
	NH	Nashua	2	(9/87)	last 15	(TBE)	(TBE)
	RI	Statewide	–	1/79	1967+	Yes	No
II	NJ	Statewide	–	2/74	all	Yes	No
	NY	NYC	10	1/82	all	Yes	No
III	DC	–	–	1/83	all	Yes	No
	MD	DC	2	2/84	last 12	Yes	No
	VA	DC	8	12/81	last 8	Yes	No
	MD	Baltimore	5	2/84	last 12	Yes	No
	PA	Philadelphia	5	6/84	last 25	Yes	No
	PA	Pittsburgh	4	6/84	last 25	Yes	No
	PA	Allentown	2	6/84	last 25	Yes	No
IV	GA	Atlanta	4	4/82	last 10	Yes	No
	KY	Louisville	1	1/84	all	Yes	No
	NC	Charlotte	1	12/82	last 12	Yes	No
	TN	Nashville	1	1/85	last 13	Yes	No
	TN	Memphis	1	8/83	all	Yes	No

Table 1-5.—Continued
Inspection/Maintenance Program Summary

EPA Region	State	City (SMSA)	No. of Counties	Program Started	Model Years Inspected	Emissions Test	Lead Test
V	IL	Chicago	3	(10/85)	1968+	(TBE)	Yes
	IL	St. Louis	2	(10/85)	1968+	(TBE)	Yes
	IN	Chicago	2	6/84	last 12	Yes	No
	IN	Louisville	2	6/84	last 12	Yes	No
	WI	Milwaukee	6	4/84	last 15	Yes	No
VI	OK	Tulsa	5	1/86	1979+	No	Yes
	LA	Baton Rouge	2	9/85	1968+	No	Yes
	TX	Houston	1	7/84	1968+	No	Yes
VII	MO	St. Louis	4	1/84	1971+	Yes	No
VIII	CO	Denver	6	1/82	1968+	Yes	No
	CO	Colorado Springs	1	1/82	1968+	Yes	No
	CO	Fort Collins	1	1/82	1968+	Yes	No
	UT	Salt Lake City	1	4/84	1968+	Yes	No
	UT	Davis	1	4/84	1968+	Yes	No
	UT	Provo	1	(7/86)	1968+	(TBE)	No

IX	AZ	Phoenix	1	1/77	last 13	Yes	No
	AZ	Tuscon	1	1/77	last 13	Yes	No
	CA	Los Angeles	–	3/84	last 20	Yes	No
	CA	Ventura	–	3/84	last 20	Yes	No
	CA	San Francisco	–	3/84	last 20	Yes	No
	CA	Sacramento	–	3/84	last 20	Yes	No
	CA	Fresno	–	10/84	last 20	Yes	No
	CA	Bakersfield	–	1/86	last 20	Yes	No
	NV	Las Vegas	1	10/83	1965+	Yes	No
	NV	Reno	1	10/83	1965+	Yes	No
X	AK	Anchorage	1	7/85	last 15	Yes	Yes
	AK	Fairbanks	1	7/85	last 15	Yes	Yes
	ID	Boise	1	8/84	1970+	Yes	No
	OR	Portland	3	7/75	last 20	Yes	No
	OR	Medford	1	1/86	last 20	Yes	No
	WA	Seattle	2	1/82	last 14	Yes	No
	WA	Spokane	1	7/85	last 14	Yes	No

Source: Council on Environmental Quality, Washington, D.C., 1985.

Thus, pre-catalyst cars contributed 73 percent of the auto emissions in 1980, but are expected to contribute only 10 percent in 1990. At the same time, total auto emissions are anticipated to drop by 67 percent from 1980–1990. Hence, the target date for maximizing emissions reductions from an I/M program should consider the model-year coverage of the program, as well as the protocols used to identify and reduce in-use emissions.

Those programs outlined in Table 1–5 that focus on only the most recent 10 or so model-year cars appear consistent with this approach. Overall costs of such targeted programs should be less than the costs of those programs requiring inspection of *all* post-1968 cars.

Historically, pre-catalyst technology (1968–1974) failed because of poor engine maintenance and tampering (that is, emissions control hardware, such as air pumps and positive crankcase ventilation valves (PCVs), was removed). For catalyst-equipped cars of 1975 to 1980 vintage, tampering became more significant than failure to keep engines tuned up, as catalysts were removed and the leaded gasoline used (which poisons catalysts). For 1981 and later model-year vehicles, failure results largely from tampering via misfueling with leaded gasoline and/or catalyst removal. EPA surveillance data show that tampering has occurred on an average of 10.2 percent of the catalyst-equipped cars in non-I/M states and 5.7 percent of cars in I/M states. Therefore, a significant question in I/M program design is, *what kind of program is needed to deter tampering?*

Current I/M programs do not deal effectively with the post-1980 technology tampering-related failure problems. Some states, such as Texas, have argued that the short tailpipe-measurement methods do not detect catalyst failure. Actual data tend to bear this out, according to EPA.[29] Hence, the Texas I/M program has only two components, a visual inspection of the emission control system, and a tailpipe-wipe test to detect the presence of leaded fuel. As pointed out previously, some states have initiated this tailpipe test for lead, in addition to using it in their emissions measurement program.

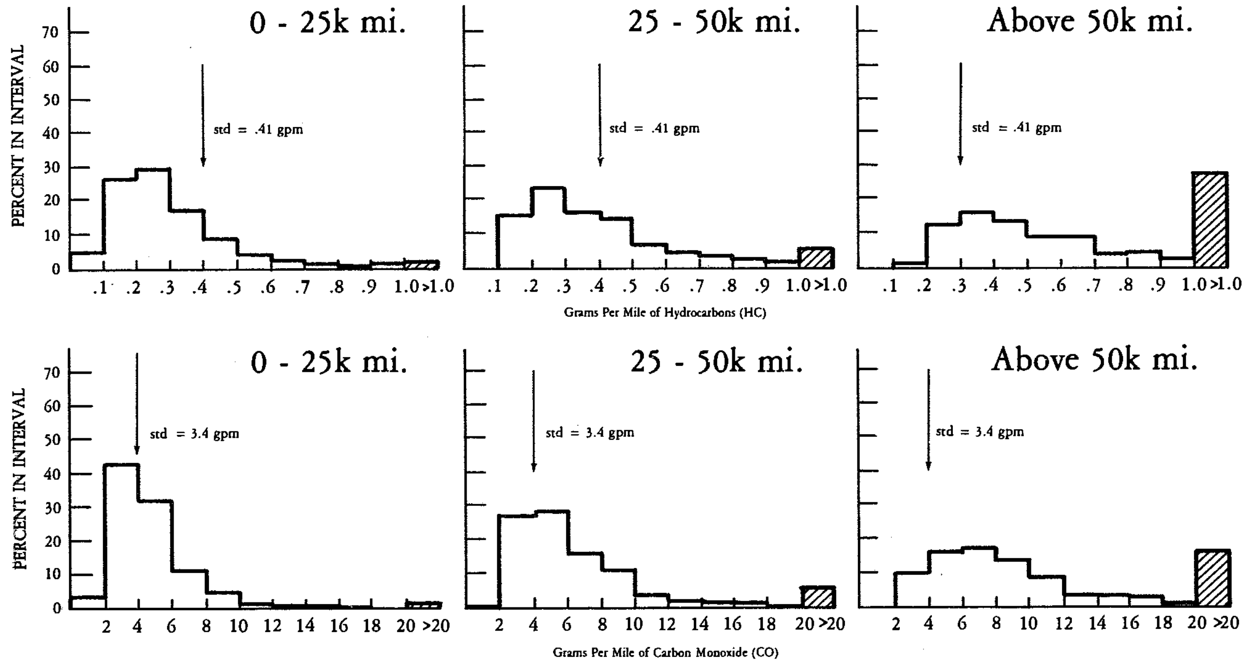
From an air quality perspective it is the emissions from the "average" car on the road that is important in determining the overall effectiveness of the Federal Motor Vehicle Control Program (FMVCP). To meet the O_3 and CO standard in most cities, the "average" car would not necessarily have to meet the current statutory limit of 0.41 grams/mile (gpm) for hydrocarbons (HC) and 3.4 gpm for CO. These standards were set as the emissions target levels that cars properly maintained should still meet at 50,000 miles. Figure 1–17, showing observed automobile emissions data from the EPA national surveillance program, illustrates that many in-use cars fall below this standard. Many "average" cars meet these standards in their early travel period (below 25,000 miles), especially for the HC standard; however, few meet either standard at higher mileages. Of course, EPA models used in projecting air quality in urban areas account for this observed deterioration with mileage, along with other factors (expected additional mileage at various mileage levels).

Current I/M Programs and Attainment of O_3 and CO Standards

One issue raised by this analysis is the extent to which current I/M programs are essential to attaining the O_3 and CO standards by 1987. A review of several state implementation programs shows that the calculated air-quality benefits

FIGURE 1-17

DISTRIBUTION OF AUTO EMISSIONS MEASURED IN IN-USE SAMPLE VERSUS MILEAGE DRIVEN



are not measurable from a timing or air-quality impact point of view. Projections were made based on the air quality and emission control relationships developed in the state implementations plans. Figure 1–18 shows the projected air quality profiles of O_3 for five major metropolitan areas — Boston, St. Louis, Washington, D.C., Louisville, and Chicago. The data show that even without I/M programs, as well as reasonable available control technology (RACT II) and transportation control measures (TCMs), most will shortly attain the standard: within two years for Washington, D.C., and within about a year or less in the four others. The attainment dates do not extend beyond 1987 except for Washington, D.C. *without* I/M. The air quality impacts due to such an extension are insignificant as well. The anticipated measured concentration on the second worst day, which is the basis of determining attainment or non-attainment, would not be discernible from the 0.12 ppm standard in three of the five cases. In Chicago and Washington, D.C., there might be at most one additional day above the attainment limit of one day per year in the originally projected year of attainment. Such exposures are within the margin of safety built into the standard to protect the public health. Two urban areas, Los Angeles and Houston, will not achieve the O_3 standard by 1987; however, they are atypical of the rest of the nation. The New York metropolitan area may be marginal in 1987, but should be in attainment by 1990.

There are also anomalous situations with respect to CO. The significance of these projected non-attainment situations must be put in clearer perspective because of the pending reconsideration of the CO NAAQS. New research information will be required to substantiate the need for the stringency of the current standard.

Previous CEQ reports (1977–1978) have shown that the risks due to automotive-related CO emissions to the susceptible population, i.e., angina patients, is not significant relative to their normal everyday angina attack risk. CEQ reported this risk to be no more than 0.122 percent in any of nine cities studied, based on 1975 air quality data. In 1985, the projected maximum risk was at least a factor of five lower than this.

It is reasonable to conclude that, whereas there appeared to be a compelling need for I/M programs when the Clean Air Act was amended in 1977, experience and current data suggest the strategy should be reevaluated. Particular consideration should be given to allowing the individual states to determine whether I/M is needed in their respective O_3 and CO problem areas, and how they can most cost-effectively implement such programs.

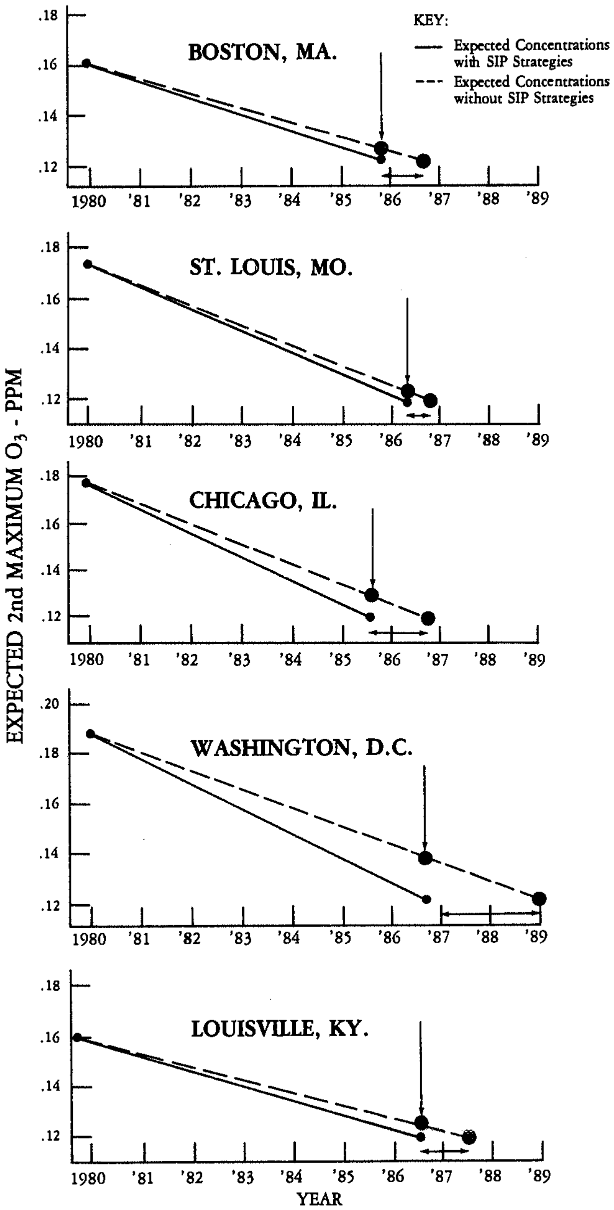
LEAD IN GASOLINE

In recognition of the health hazard posed by lead, the Environmental Protection Agency promulgated the first series of "lead phasedown" regulations in 1973. These regulations were designed to reduce the amount of lead used in gasoline by about 65 percent. Further, companion regulations were promulgated to require the availability of unleaded gasoline for 1975 and later model years of light-duty vehicles. These two sets of regulations should have resulted in very little lead still used in gasoline by the mid-1980s.

The regulations were based on a "pooled standard" method, wherein each refinery would divide its quarterly lead usage by the gallons of total production.

FIGURE 1-18

COMPARISON OF SIP FORECASTS WITH AND WITHOUT I/M, RACT II AND TCM'S IN FIVE AQCR'S



P00000123107

Thus, a refiner who had a large unleaded production could make leaded gasoline with a higher concentration of lead since it would be offset under a pooled standard. This concept would also encourage the production of unleaded gasoline. The standard itself was designed to phase down the permitted amounts of lead through a series of five-step reductions. After court challenges and modifications to the rule, the date for compliance with the final level of .5 grams/gallon was delayed until October 1, 1980, for most refineries and October 1, 1982, for "small" refineries.

In 1982, EPA proposed a complete review of the regulations. After two formal proposals, two public hearings, and over one thousand written comments, new regulations were promulgated on August 28, 1982. These regulations required all refineries to meet the same standard. Thus, there was no longer a distinction between "small" and "large" refineries. Further, importers were required to meet the same standard. The standard itself was 1.10 grams of lead per *leaded* gallon (gplg). This change from a pooled gallon to a leaded gallon standard was designed to put all entities on an equal footing and no longer to allow larger refiners with a greater percentage of unleaded gasoline an opportunity to raise lead concentrations in leaded gasoline. The 1.10 gplg level approximated that level of lead actually being used in 1982. The net effect would be to lower total lead usage 34 percent over the period 1983–1990 compared with the former .5 gram per pooled gallon standard.

Further, the concept of lead allocations was introduced under this procedure. Refiners who are not in compliance with the quarterly standard may obtain lead rights from refineries that have complied and have produced gasoline below the permitted maximum. Despite some initial skepticism, this process of buying and selling lead rights has worked quite well. In the third calendar quarter of 1984 (the last full quarter for which computerized data are available), 70 percent of refineries engaged in this type of trading.

The total mass of lead has indeed decreased substantially. In fact, in 1984 the estimated usage of lead in gasoline was about 20 to 25 percent of its peak usage in the late 1960s and early 1970s. Thus, the original goal has even been surpassed. Leaded gasoline now comprises about 40 percent of the total product sold, and each gallon has about half the lead that was used prior to the regulations.

While the progress in reducing the total amount of lead has been significant, two concerns have prompted EPA to take even further action to decrease the amount of lead in gasoline.

Health Effects

The first concerns arose from new findings of adverse health effects from exposure to lead. These effects have been detected at levels of lead in blood previously considered safe. Many of these effects may be most pronounced in children. The second concern involves the persistent use of leaded gasoline by vehicles designed to use unleaded gasoline. This practice, known as fuel switching, has ruined millions of catalytic converters and has resulted in increases in controlled pollutants and increased lead emissions.

The continuing concern about the harmful health effects of lead has forced EPA to reopen this issue several times. Initially, there was some question

concerning the identity of the sources of exposure to lead in both adults and children. Recent information based on the Second National Health and Nutrition Evaluation Survey (NHANES II) has demonstrated a startling correlation between blood lead levels and gasoline lead. This correlation is shown in Figure 1-19. Further work (isotope studies) designed to demonstrate a causal relationship tend to confirm that gasoline lead does indeed play a major role in blood lead and its symptoms. This relationship was widely publicized in the September 2, 1982, issue of the *New England Journal of Medicine*.[30]

In early 1985, the Centers for Disease Control (CDC) lowered the threshold level for blood lead in children. The new level, 25 micrograms of lead per deciliter of blood (25 ug/dl) is the level above which followup treatment and screening is required; this level replaces the former threshold of 30 ug/dl. Based on the NHANES II data, the new level triples the number of children who require treatment.

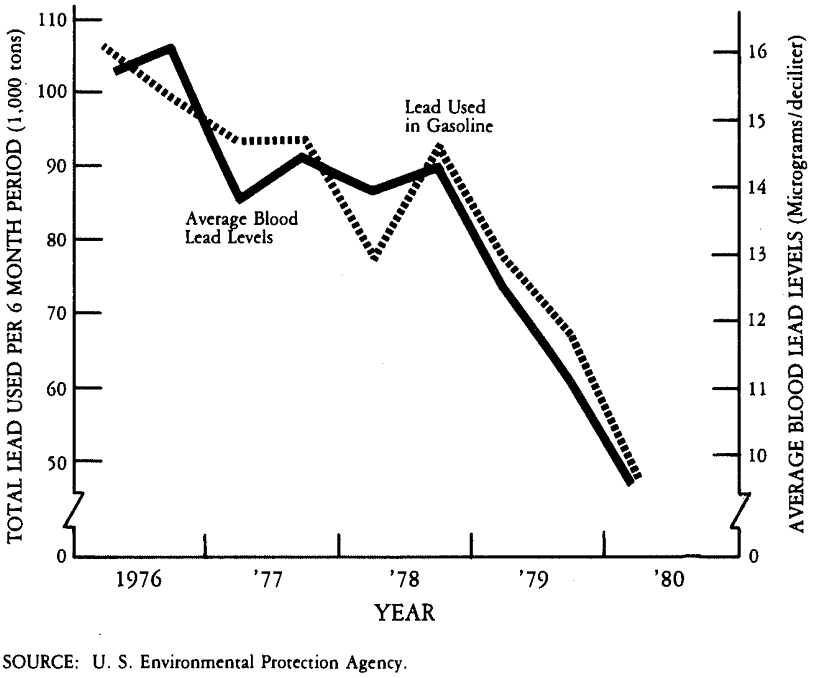
Fuel Switching

Fuel switching — the misuse of leaded gasoline in vehicles that require unleaded — has been a persistent problem despite EPA enforcement actions. This practice poisons the catalytic converter causing four- to eight-fold increases

FIGURE 1-19

LEAD USED IN GASOLINE PRODUCTION AND AVERAGE NHANES II BLOOD LEAD LEVELS

(Feb. 1976 - Feb. 1980)



SOURCE: U. S. Environmental Protection Agency.

in hydrocarbons and carbon monoxide and about three-fold inceases in NO_x in newer vehicles equipped with three-way catalysts. EPA currently estimates that 16 percent of the vehicles that should use unleaded gasoline have used leaded gasoline. In addition to the marked increase in these pollutants, the amount of leaded gasoline used in these "misfueled" vehicles has caused EPA estimates for leaded consumption to be greatly exceeded, and has brought into question whether the "natural phasedown" of leaded gasoline (due to fleet turnover) would ever occur.

The major reason for fuel switching appears to be the price differential between regular grades of leaded and unleaded gasoline. This differential has been about 6 to 7 cents at the pump. EPA has instituted an aggressive enforcement program designed to reduce fuel switching. The measures include direct investigations and notices of violations issued to offending gasoline stations by both EPA and state personnel, the encouragement of states to incorporate anti-fuel switching programs in their inspection and maintenance programs, and increased public awareness. This latter includes cost demonstrations that fuel switching, rather than saving money, costs motorists in increased maintenance and replacement expenditures. Despite these efforts, however, fuel switching continues, indicating that a direct reduction or elimination of lead in gasoline may be the only option available to reduce future misfueling.

The Continued Phasedown of Lead from Gasoline

With the two problems of fuel switching and lead health effects, it appears prudent simply to eliminate lead from gasoline. This approach, while the most direct to solving the problem, encounters some difficulties.

The primary problem has to do with valve recession in certain gasoline engines. In addition to being an octane booster, lead also serves as a valve seal lubricant. Some vehicles may depend on at least small amounts of lead for lubrication. EPA has reviewed these possible needs and has identified laboratory studies that tend to indicate that a level of 0.04 to 0.07 grams per leaded gallon (gplg) should be sufficient to meet the lubrication needs. Other studies of in-use vehicles noted by EPA suggest that no lead may be required at all.

The need for lead appears to be a function of engine operating speed and the load on the engine. The higher the severity of operation, the more likely the need for some lead. For this reason, there is some concern that while light-duty vehicles might not require any lead, certain farm engines, boats, or heavy-duty trucks may be more susceptible to the valve recession problem. To provide some protection for these engines, EPA has determined that 0.10 gplg is the level at which the substantial portion of valves should be satisfied.

Based on this information, on March 3, 1985, EPA promulgated a final rule establishing a 0.10 gplg standard on January 1, 1986, and a 0.50 gplg interim standard beginning July 1, 1985. EPA also expressed its continuing concern about even this low level of lead and suggested it might issue rules to eliminate lead in gasoline as soon as January 1, 1988.

EPA's Benefit/Cost Analysis

Two general classes of benefits were estimated in this analysis. The first is

the direct benefits from reducing individuals' exposures to airborne lead, which include a reduction of adverse effects in children and the effects in adults relating to hypertension. The second class of benefits concerns those primarily associated with an elimination of fuel switching, such as increased fuel economy, a reduction of health and welfare damages associated with pollutants controlled by catalytic converters, and decreased vehicle maintenance costs to consumers. Benefits in this latter category were also attributed to vehicles that currently use leaded gasoline legally. The costs that were computed with respect to lead phasedown all involved increased costs to refineries producing leaded gasoline.

By using several large data sets and examining the correlations between blood lead and gasoline lead, it was possible statistically to estimate how blood lead levels respond to changes in gasoline lead. It was estimated that in 1986 alone, a regulation of 0.10 gplg would prevent the blood levels of 172,000 children from exceeding the 25 ug/dl blood lead standard recently set by the CDC. EPA further subdivided those children in two categories: children exceeding the CDC level, requiring medical care, and a subset of those children who may suffer cognitive effects from exposure to lead below the CDC level, therefore requiring compensatory education. Under these categories EPA was then able to monetize the health benefits of reducing lead to 0.10 gplg. These benefits from this category alone range from about $600 million in 1986 to nearly $350 million in 1992. These estimates are shown in Table 1–6.

The fuel switching problem, which causes large increases in emissions from poisoned catalysts, would also be substantially reduced with a 0.10 gplg standard. EPA modeling has shown that the production cost of making leaded gasoline (at 89 octane) at 0.10 gplg exceeds that of producing regular grades of unleaded gasoline (at 87 octane). This difference in production cost should serve at least to lower the retail price differential. It has therefore been assumed that 80 percent of misfueling will be eliminated by this rule. Based on two methods of evaluation (direct health effects, implicit cost of emission control equipment), EPA has estimated a saving of over $200 million per year. (See Table 1–6.)

Vehicle maintenance costs are also reduced when less lead is used in the gasoline because of the corrosive effects of lead. EPA has estimated that the benefits of fewer exhaust system replacements, increased intervals between spark

Table 1–6. Year-by-Year Costs and Monetized Benefits of Final Rule Assuming Partial Misfueling (millions of 1983 dollars)

	1985	1986	1987	1988	1989	1990	1991	1992
MONETIZED BENEFITS								
Children's health effects	$223	$600	$547	$502	$453	$414	$369	$358
Conventional pollutants	0	222	222	224	226	230	239	248
Maintenance	102	914	859	818	788	767	754	749
Fuel economy	35	187	170	113	134	139	172	164
TOTAL MONETIZED BENEFITS	360	1924	1799	1658	1601	1551	1534	1520
TOTAL REFINING COSTS	96	608	558	532	504	471	444	441
NET BENEFITS	264	1316	1241	1126	1097	1080	1090	1090

plug changes, and fewer oil changes save on average about $17 per year for a vehicle driven about 10,000 miles. The aggregate benefits for all the vehicles currently using leaded gasoline as shown in Table 1–6 range from over $900 million in 1986 to nearly $750 million in 1992.

The use of low lead gasoline also improves fuel economy due to the higher energy content of low lead fuel and the reduction of fouled oxygen sensors in newer misfueled vehicles. The total estimated fuel economy benefits exceed $100 million in most years.

The benefits from children's health effects, conventional pollutant reductions, reduced vehicle maintenance, and increased fuel economy total more than $1.5 billion per year in the years 1986–1992; and over $300 million in the second half of 1985.

Needless to say, these benefits do not accrue without some costs. Lead is used by refiners to boost the octane of gasoline. Without lead, some other methods must be used, such as other additives or additional processing of crude oil. These methods are all more costly than the addition of lead. To determine the cost to the refinery industry of this rule, EPA used a Department of Energy linear programming model to derive minimum cost methods to meet gasoline demand. The model was run twice, once for the 1.10 gplg current standard, and then for the 0.10 gplg new standard. The difference between the total costs from each run is the estimated cost of the rule. Several sensitivity runs were also made to invoke constraints on the model to reflect real-world limitations in the ability of the refining industry to fully optimize production. The costs of the rule were estimated at about $500 million per year from 1986–1992 and nearly $100 million in the last half of 1985.

The major findings of this study can be summarized in the computation of net benefits (benefits minus costs). Net benefits have been estimated at over $1 billion for each year between 1986 and 1992, and about $260 million for the second half of 1985 (1983 dollars).

As a companion rule to the March 1985 phasedown standards, EPA is instituting "banking" procedures. Under the banking rule, refiners that reduce their lead usage below the 1.10 gplg standard in the first half of 1985 could save those reductions and use them in 1986 and 1987. In this manner, refineries could follow their own least-cost route to the 0.10 gplg 1988 standard and therefore reduce total nationwide industry costs. Because banked rights are freely transferrable among refiners, they increase individual refineries' flexibility by shifting lead usage from 1985 to 1986 and 1987 without increasing the total amount of lead used. EPA estimates that the banking rule may reduce the phasedown rule's cost by about $200 million in the 1985–1987 period.

Ban Under Consideration

The final EPA regulation of March 1985 specified a standard of 0.50 gplg effective July 1, 1985, and 0.10 gplg effective January 1, 1986. In addition, a final rule for banking procedures was published shortly thereafter.

Accompanying the final rule was a supplemental notice of proposed rulemaking. This additional notice suggested that the Agency would consider completely banning lead in gasoline perhaps as soon as January 1, 1988. Three reasons were posed for this possible acceleration of EPA action. First, the total

elimination of lead in gasoline would considerably reduce the incidence of hypertension, strokes, heart attacks, and even mortality. Second, the requirement of lead to provide valve lubrication in some vehicles may have been exaggerated. Information obtained by EPA based on vehicle fleets operated by the U.S. Army and the U.S. Postal Service seems to show that no lead may be required at all. These two entities have run large fleets on unleaded gas for several years, even though the vehicles had been designed to use leaded gas, and no abnormal valve damage has been reported. Third, based on the comments of refiners and marketers, EPA is uncertain whether the 0.10 gplg standard will eliminate fuel switching. These comments indicated that comparable production costs may not lead to comparable retail prices. If leaded regular grades continued to be priced lower than comparable unleaded grades, the major incentive for fuel switching would remain.

The EPA has studied lead in gasoline extensively since its first phasedown promulgation in 1973. During its peak year, approximately 200,000 metric tons of lead were used in gasoline. Starting in 1986, this number will be reduced to about 4,000 metric tons, representing a 98 percent decrease. The health and welfare benefits make the current regulation, as well as the proposal to eliminate lead in gasoline, a sensible public policy from both a public health and an economic perspective.

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19. 40 Fed. Reg. 58416 (December 16, 1975).
20. *ASARCo Inc. vs. EPA*, 578 F. 2d 319 (D.C. Court of Appeals, 1978).
21. 44 Fed. Reg. 71779 (December 11, 1979).
22. 47 Fed. Reg. 15076 (April 7, 1982).
23. "Netting" allows all new and old facilities at a plant to be grouped together for determining whether federal pre-construction permit requirements are applicable. Thus, a new facility at an existing plant would not be subject to such requirements if its emissions were offset elsewhere in the plant. Because of the *ASARCo* decision, however, netting cannot be used to determine applicability of NSPS. This apparent contradiction results from the fact that federal pre-construction permit requirements are based on emissions increases at a "source," and the courts have ruled that EPA has the flexibility to define source as broadly as a single plant. See *Chevron, U.S.A. vs. NRDC*, 104 S. Ct. 2778, 14 ELR 20507 (June 25, 1984) overruling *NRDC vs. Gorsuch*, 685 F. 2d 718, 12 ELR 20942 D.C. Cir. (1982) on the legality of netting in nonattainment areas; and *Alabama Power vs. Costle*, 636 F. 2d. 323, D.C. Court of Appeals (1979) on its legality in attainment areas.
24. Banking of emission reduction credits allows firms to reduce transaction costs in identifying and locating emission reduction credits.
25. U.S. Environmental Protection Agency, "Emission Trading Status Report," (October 1, 1984), Regulatory Reform Staff.
26. 48 Fed. Reg. 48368 (October 18, 1983).
27. 50 Fed. Reg. 3688 (January 25, 1985).
28. Communication with U.S. Environmental Protection Agency Mobile Source Laboratory, Ann Arbor, MI.
29. *Ibid.*
30. Kathryn R. Mahaffey, Ph.D., *et al.*, "National Estimates of Blood Lead Levels: United States, 1976–1980: Association with Selected Demographic and Socioeconomic Factors," *New England Journal of Medicine*, September 2, 1982 (Vol. 307, No. 10) Boston, Mass. pp. 573 ff.

Chapter 2
Water Quality

Federal and state water quality programs have undergone a change in emphasis in recent years. In the period just after 1972, activity concentrated on establishing or improving regulatory permit programs to limit municipal and industrial "point source" discharges to surface waters. Attention during those years focused on "conventional" pollutants that had been known for some time to harm water quality or public health. Later in the decade and into the 1980s, the focus has broadened to include "nonpoint" sources of pollution and toxic pollutants from point and nonpoint sources. Most recently, attention in many states has also expanded from streams and rivers to increased emphasis on lake quality and ground water.

Although the data presented in the following sections document improve-ents in water quality in many areas, a number of serious problems remain. These include low concentrations of toxic substances in fish, sediments, and water. Resource constraints compel the development of lower-cost waste treatment technologies to control both point and nonpoint sources of water pollution.

State and local governments have conducted studies to evaluate the extent of nonpoint sources of pollution and have emphasized education and demonstration projects to promote use of the "best management practices" available to reduce or prevent runoff.

Agricultural nonpoint pollution is generally being addressed through voluntary programs. Cost-sharing is often used to subsidize installation of suitable controls. In a few instances, states have adopted legislation enabling or requiring urban localities to manage their storm water runoff, with the state agency providing technical assistance. Nonpoint pollution sources from mining and from construction activities are the only categories commonly subject to state-initiated regulation, although federal mine land reclamation programs are being used to deal with drainage from abandoned mines.

States and EPA are also developing new approaches to move beyond the Clean Water Act's regulations that mandate use of the "best available technology" to eliminate the toxicity of discharges to surface waters. The Association of State and Interstate Water Pollution Control Administrators (ASIWPCA) has endorsed incorporating a Toxicity Elimination and Management Strategy (TEAMS) into the national clean water program. Under TEAMS, control programs are to be directed at eliminating toxic effects; the results of biological monitoring are the key determinants in judging such effects. EPA has developed an integrated regulatory strategy through which it and the states will use both biological and chemical methods to address toxic pollutants from industrial and municipal sources.

These and other emerging water quality issues that demand continuing attention in the years ahead are further discussed in the issues section of this chapter.

Conditions and Trends

The water medium includes widely differing phases of the hydrologic cycle, ranging from fast-moving, fresh-water streams, to extremely slow-moving ground water, to estuaries and coastal marine waters. Consequently, the parameters for characterizing acceptable water quality vary substantially from one water body type to another, and tend to be both general, such as the "fishable and swimmable" goal of the Clean Water Act, and specific, using water quality criteria for pollutants. As a result, the reports prepared by government agencies assessing water quality often rely on the subjective judgment of knowledgeable persons in the field, as well as on monitored data.

SURFACE WATERS

Water quality trends since 1972 indicate that, although the degradation of the nation's surface waters has been arrested since enactment in 1972 of amendments to the Federal Water Pollution Control Act, the statutory goal of restoring the nation's waters to "fishable and swimmable" conditions has not been achieved everywhere. The challenge ahead is twofold—to identify those water quality measures that are most indicative of the health of the nation's waters and to design policies that effectively remedy the remaining significant sources of degradation.

This review of water quality conditions and trends is based on reports prepared by the federal government, usually in cooperation with state or local governments, or private associations and professional organizations. It presents recent water quality data, as observed in the *States' Evaluation of Progress 1972–1982* report,[1] as reported by the states and summarized by the Environmental Protection Agency in the *National Water Quality Inventory: 1984 Report to Congress*,[2] as demonstrated by the fishable nature of surface waters in the 1982 *National Fisheries Survey*,[3] and as indicated by the status and trends of selected pollutants reported in the U.S. Geological Survey (USGS) *1984 National Water Summary*.[4] In addition to quantitative physical and chemical parameters, state trends analyses are often based on professional judgment.

States' Evaluation of Progress 1972–1983 (STEP)

This comprehensive report on the quality of the nation's surface waters represents the states' evaluation of 42 percent of the nation's streams—758,000 stream miles. Of these, roughly 169,000 miles of streams were monitored in 1982 for long-term trends in water quality. The states also evaluated nearly half (16,320,000 acres) of the nation's 33,450,000 acres of publicly owned lakes and reservoirs. The quality of 9.7 million of these acres was monitored for trends in 1982.

Some states evaluated close to 100 percent of their surface water; others assessed a limited part. The proportion varied from state to state, depending on the amount of waters, the distribution and severity of pollution sources, and the availability of funds for monitoring.

Of the streams evaluated, 47,000 miles improved in quality, 296,000 miles maintained the same quality, 11,000 miles degraded, and changes for another

90,000 miles were unknown. Of the lakes evaluated, 390,000 acres showed improved water quality, 10,130,000 acres maintained the same quality, 1,650,000 acres were degraded, and 4,150,000 acres were unknown or not reported.

Attaining Designated Uses of Surface Waters: The Clean Water Act establishes as a goal fishable/swimmable water quality "providing for the protection and propagation of fish, shellfish, and wildlife, and for recreation in and on the water". . ."wherever attainable." Most of the nation's surface waters have these uses designated as their ultimate quality targets.

Over 120,000 stream miles are designated for uses more stringent than fishable/swimmable, such as for drinking or food processing. Only 32,000 miles have stream standards set for less stringent uses. Tables 2–1 and 2–2 show that by far the majority of surface waters assessed fully support the uses for which they are designated (84 percent of lakes and reservoir acres and 64 percent of river and stream miles). These figures increase to 86 percent for rivers and streams and 94 percent for lakes when waters partly supporting uses are included.

Treating Municipal Waste Water: The provision of adequate municipal waste water treatment to a growing population has been one major accomplishment

Table 2–1. Stream Water Quality 1972–1982[1]

	1982		1972	
Use Category	**Miles**	**Percent**	**Miles**	**Percent**
Supporting Uses	488,000	64	272,000	36
Partly Supporting Uses	167,000	22	46,000	6
Not Supporting Uses	35,000	5	30,000	4
Unknown or Not Reported[2]	68,000	9	410,000	54

[1]Of 758,000 river and stream miles assessed.
[2]While information on the water quality of many of these stream miles was not available for 1972, some proportion of them fall into each of the levels of use support.

Source: Association of State and Interstate Water Pollution Control Administrators in cooperation with the U.S. Environmental Protection Agency, *The States' Evaluation of Progress 1972–1982* (Washington, D.C.: 1984), p. 4.

Table 2–2. Lake Water Quality 1982[1]

	1982	
Use Category	**Acres**	**Percent**
Supporting Uses	13,800,000	84
Partly Supporting Uses	1,700,000	10
Not Supporting Uses	400,000	3
Unknown	400,000	3

[1]Of 16.3 million lake and reservoir acres assessed in 1982.

Source: Association of State and Interstate Water Pollution Control Administrators in cooperation with the U.S. Environmental Protecrion Agency, *The States' Evaluation of Progress 1972–1982* (Washington, D.C.: 1984), p. 5.

of the past decade. In addition, the level of sewage treatment provided to the American public rose enormously.

Of the approximately 224 million people in the United States in 1982:

- 142 million were served by the generally required secondary treatment or by more advanced levels—this reflects an increase of 57 million people since 1972;
- Approximately 23 million people were served by facilities that provide less than secondary treatment;
- The population served by sewer lines carrying raw waste water to streams dropped from five million in 1972 to one million in 1982;
- The number of people requiring but not receiving public sewage collection and treatment dropped from 21 million to 14 million; and
- About 44 million people did not need municipal sewage systems because they were adequately served by onsite disposal systems.

Upgrading the level of sewage treatment produces direct benefits by reducing pollutant discharges to waterways. The most widely used measure of municipal pollution is the extent to which the treated waste's organic content depletes the receiving water's dissolved oxygen, reducing that available to fish and other aquatic life. Municipal organic pollution decreased dramatically during the past decade. Treatment capabilities increased at a higher rate than the nation's population grew. Between 1972 and 1982, the amount of oxygen-demanding pollutants entering the nation's sewage plants grew by 12 percent. During that same span, the amount released into waterways dropped by 46 percent. Had treatment capabilities not improved at a faster rate than the nation's population was growing, states collectively estimate that 1982 discharges would have been 191 percent greater than the actual levels.

Treating Industrial Waste Water: Industry has responded positively to the mandates of the Clean Water Act. During the past decade, industrial dischargers have invested heavily to reduce water pollution.

Under the Act, industries must meet discharge limits based on the "best practicable" and "best available" treatment technologies as defined by EPA. One key measure of industrial progress is the greatly increased level of compliance with state or federally established discharge limitations, especially for plants with the largest waste water flows. On this basis, from 1972 to 1982, municipal facilities improved in compliance from 33 percent to 76 percent, and industrial facilities from 36 percent to 78 percent.

Controlling Nonpoint Sources of Pollution and Toxic Pollutants: 45 states reported on the severity and geographical extent of nonpoint sources of pollution, and indicated that agricultural sources caused the most severe and widespread pollution. They also reported that nonpoint pollution comes from a variety of sources, including urban areas, mining, land disposal, construction, dams and channels, forests, and saltwater intrusion, as well as agricultural sources. In addition, 41 states reported that identifying and controlling toxic pollutants are among the major problems they expect to confront in the years ahead.

National Water Quality Inventory

The information provided by the *1984 National Water Quality Inventory* (also

known as the state 305(b) report) and by other EPA data show that significant success has been achieved in cleaning up the nation's waters. Many of the most severe pollution problems that plagued our waterways in the 1960s and 1970s have been abated. Most of the nation's rivers, lakes, and estuaries are able to support, to a significant degree, the uses for which they have been designated. These findings in large measure are consistent with the findings of the STEP report previously discussed, and are also based on additional information reported by the states.

Each water body in a state has one or more specific uses designated for it. These water uses may range from coldwater fisheries and primary contact recreation, to irrigation or industrial cooling purposes where fishable and swimmable uses are not attainable. The state must ensure that the water body's quality is sufficient to meet these uses.

As a measure of water quality status, the states were asked by EPA to provide information on the extent to which their rivers, lakes, and estuaries support the beneficial uses for which they have been designated. These uses were found to be supported in most waters. Table 2-3 depicts the degree to which beneficial uses are supported in assessed waters, as reported by the states in 1984.

Rivers and Streams Supporting Designated Uses: A total of 40 states responded to this request to report the degree to which their rivers supported uses. Some 325,619 river miles were assessed. Of these, 237,154 or 73 percent were reported to support fully their designated uses. Partial support of uses was reported in 45,692 river miles, or 14 percent; and 19,600 miles, or 6 percent, did not support their uses. Degree of use support in an additional 23,173 miles (8 percent) was unknown.

The states generally focus their assessment efforts on those waters that are thought most likely to be affected by pollution. Therefore, while the 325,619 river miles assessed by the states in 1984 are only a fraction of the nation's estimated 1.8 million total miles, the remaining unassessed waters are thought to be of equal or better quality.

National progress toward the Clean Water Act fishable/swimmable goal—that is, providing for the protection and propagation of a balanced population of fish, and allowing recreational activities in and on water—is displayed in Table 2-4 for 19 states. These percentages vary widely among the states, from

Table 2-3. A Summary of Water Quality Status[1]

Water body Type (Total Assessed)	Fully Support Uses	Partly Support Uses	Do Not Support Uses	Unknown
Rivers & Streams (325,619 mi)	73%	14%	6%	7%
Lakes & Reservoirs (9,577,270 ac)	78%	16%	5%	1%

[1]Based on information from 40 states that reported use support numbers for rivers and 30 that reported lake numbers.

Source: U.S. Environmental Protection Agency, *National Water Quality Inventory: 1984 Report to Congress* (Washington, D.C.: 1985).

Table 2-4. River Miles in 20 Reported States Meeting the Fishable/Swimmable Goal of the Clean Water Act

State	Total River Miles	Assessed River Miles	Percent Fishable	Percent Swimmable	Percent Swimmable/ Fishable
Arkansas	11,202	11,202	94	53	-
Delaware	-	491	-	-	43
Maine	31,806	2,652	-	-	66
Maryland	9,300	7,440	-	-	92
Massachusetts	10,704	1,630	-	-	47
Minnesota	91,871	2,708	94	39	-
Mississippi	10,274	10,274	-	-	90
Missouri	18,750	18,670	99	21	-
Montana	19,168	17,251	95	96	95
Nebraska	24,000	7,152	74	19	-
New Hampshire	14,544	14,544	-	-	93
New Mexico	3,500	3,500	100	-	-
North Carolina	40,207	37,378	-	-	81
Ohio	43,919	4,949	-	-	62
Oregon	90,000	3,500	-	-	74
Rhode Island	724	724	-	-	81
South Carolina	9,679	2,489	-	-	57
Texas	80,000	16,120	-	-	90
Vermont	4,863	2,325	-	-	93
Virginia	27,240	4,964	81	46	-

Source: U.S. Environmental Protection Agency, *National Water Quality Inventory: 1984 Report to Congress* (Washington, D.C.: 1985).

43 percent of Delaware's 491 assessed river miles, to 95 percent of Montana's 14,544 assessed river miles. In some cases, these variations may be attributable as much to different assessment techniques as to actual differences in water quality. For instance, one reason for such differences in variations is how "swimmable" conditions are evaluated.

Five states reported on their progress toward the goal by separating the fishable from the swimmable component. In each case, a far greater percentage of the assessed river miles was found to be fishable than was found to be swimmable.

Several states offered other explanations for low swimmability numbers. Delaware reported that the majority of its miles not meeting the goal are not swimmable due to the strong currents and turbid conditions of estuarine rivers. Therefore, the goal is not being met because of physical and not water-quality reasons. Arkansas also notes that most of its streams that fail to meet the swimmable goal are not designated for swimming because of other characteristics that make them unsuitable, for example, intermittent, shallow waters, sluggish or naturally turbid waters, and streams with steep banks.

Lakes and Reservoirs Supporting Designated Uses: In 1984, 30 states and

jurisdictions reported on the degree to which their lakes and reservoirs support designated uses. A total of 9,577,270 acres of lakes were assessed. Of these, 7,442,034 acres, or 78 percent, were reported to be fully supporting their designated uses. Partial support of uses is reported in 1,524,300 acres (16 percent), and 530,286 acres (5 percent) are reported as not supporting their designated uses. In 80,640 acres (1 percent of the total) the degree of use support is unknown.

Although fewer lake acres were reported on than in the STEP report, the percentage of lake waters fully or partly supporting uses is the same (94 percent), while waters determined to fully support uses were estimated to be somewhat higher (78 percent, rather than 64 percent). This consistent information indicates that the nation's assessed lakes are of good overall quality.

The nation's lakes and reservoirs, like its flowing waters, are also traditionally measured in terms of their ability to meet the fishable and swimmable goal of the Clean Water Act. Table 2–5 depicts information available from the 1984 state 305(b) report on the degree to which assessed lakes meet the goal. Only nine states provided this information for a total of 1,941,101 acres. In these states a high percentage of lake acres is fishable and swimmable.

Causes of Nonsupport for Designated Uses: Figure 2–1 illustrates the frequency with which pollutants were reported by the states as being "statewide concerns." The most widely reported parameter of concern is bacteria. Biochemical oxygen demand, low levels of dissolved oxygen, and high nutrient levels were also widely reported, followed by turbidity and total suspended solids. Metals and other toxics also figure highly among state-reported parameters of concern. A number of other pollutants were reported less frequently, including temperature, sulfates, and oil and grease.

The 1984 National Water Quality Inventory classifies as "toxics" those pollutants that may have an adverse impact on human health or the aquatic environment at relatively low concentrations. This group includes some of the metals, pesticides, and other synthetic organic pollutants that contaminate water, fish tissue, and bottom sediments. Thirty-seven states reported the occurrence of toxics in their waters at elevated levels, and an additional eight states have detected the presence of toxics. Nineteen states consider toxic pollution as a special concern. Table 2–6 lists the number of states that reported elevated levels of specific toxics. The Food and Drug Administration (FDA), EPA, and the states have established "action" levels, concentration of toxic chemicals in fish tissue at which there is potential for harmful human health effects if the fish is consumed. In 1984, 33 states reported detectable levels of toxic pollutants in fish tissue; 21 reported the occurrence of concentrations exceeding FDA action levels.

As illustrated in Table 2–7, most pollutants can enter the aquatic environment from a variety of point and nonpoint sources. The states were also asked to supply estimates of the extent to which sources of pollutants inhibit full support of water uses. Reported information was grouped by geographic region as indicated in Figure 2–2, and is reported in Tables 2–8 and 2–9. These tables depict how extensively streams and lakes throughout the country are achieving their designated uses and the point and nonpoint sources of pollution that are inhibiting their progress.

Assessments made by 47 states depict the extent of nonpoint-source pollution in the United States. Twenty-four states found that nonpoint-source

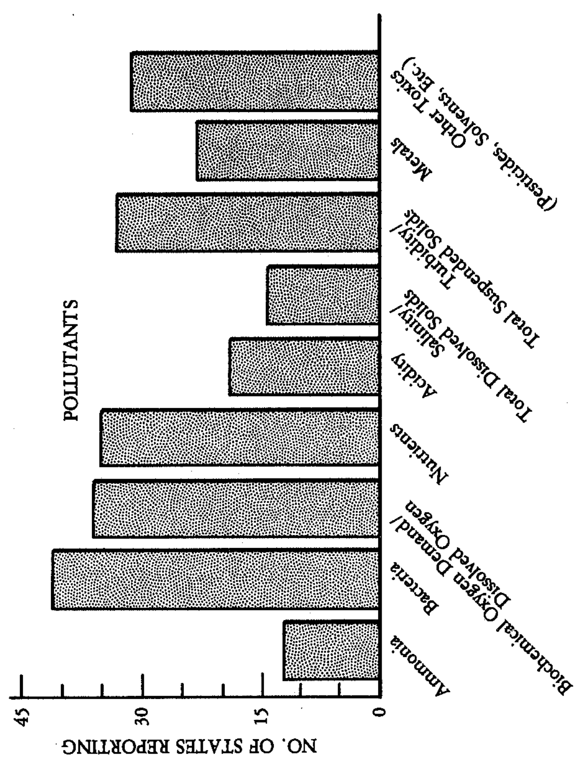
Table 2-5. Lake Acres Meeting the Fishable/Swimmable Goal of the Clean Water Act

State	Assessed Lake Area (Acres)	Percent Fishable/Swimmable
Delaware	,1,517	92
Kentucky	358,214	100
Maryland	20,696	100
Mississippi	495,191	96
Nebraska	107,726	99
New Hampshire	185,620	85
North Carolina	315,335	81
Rhode Island	16,520	96
South Carolina	440,282	72

Source: U.S. Environmental Protection Agency, *National Water Quality Inventory: 1984 Report to Congress* (Washington, D.C.: 1985).

FIGURE 2-1

POLLUTANTS MOST WIDELY REPORTED BY THE STATES



SOURCE: U. S. Environmental Protection Agency, *National Water Quality Inventory: 1984 Report to Congress* (Washington, D.C.: 1985).

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Table 2-6. Toxics Reported By States at Elevated Levels

Toxics	No. of States Reporting Elevated Levels
Metals:	
Mercury	21
Copper	16
Zinc	14
Lead	13
Cadmium	11
Chromium	11
Arsenic	6
Nickel	5
Silver	4
Selenium	3
Pesticides:	
Chlordane	15
DDT and its metabolites	8
Dieldrin	7
Other Organics:	
PCBs	22
Phthalate esters (for example, di-n-butyl-phthalate)	6
Halogenated aliphatics (for example, carbon tetrachloride)	5
Phenols	5
Monocyclic aromatics (for example, benzene)	4
Dioxin	3

Source: U.S. Environmental Protection Agency, *National Water Quality Inventory: 1984 Report to Congress* (Washington, D.C.: 1985).

pollution is a major source of water degradation; 21 more reported that nonpoint sources are a problem of as yet undetermined magnitude; and two states classified nonpoint sources as potential pollution problems.

Streams—Table 2–10 is a summary of the causes of nonsupport of designated uses in 28 reporting states. Point sources affect 48 percent of those assessed river miles in which uses are impaired.

Municipal sources of pollution affect 36 percent of assessed stream miles with impaired uses; industrial sources, 11 percent; and combined sewer overflows, 1 percent. According to these estimates, nonpoint sources affect 39 percent of assessed stream miles. In addition, natural sources affect 2 percent, and the remaining 11 percent of streams are affected by "other" or undetermined sources of pollution.

Lakes—Despite the high percentage of waters of lakes and reservoirs that support their designated uses, significant pollution problems remain. Nineteen

Table 2-7. Sources of Pollution

Pollutant/ Possible Sources	Pollutant Category
BOD/DO	Municipal waste water treatment plants; industries (particularly pulp and paper mills); combined sewers; natural sources
Bacteria	Municipal waste water treatment plants; combined sewers; urban runoff; feedlots; pastures and rangelland; septic systems; natural sources.
Nutrients	Municipal waste water treatment plants; agriculture; septic systems; silviculture; combined sewers; construction runoff.
Suspended solids/ turbidity	Agriculture; urban runoff; silviculture; construction runoff; mining; industries; combined sewers.
Total dissolved solids	Agriculture; mining; urban runoff; combined sewers.
pH	Atmospheric deposition; mine drainage.
Ammonia	Municipal waste water treatment plants; combined sewers.
Toxics	Industries; municipal waste water treatment plants; agriculture; land disposal of wastes; silviculture; urban runoff; spills; combined sewers.

Source: U.S. Environmental Protection Agency, *National Water Quality Inventory: 1984 Report to Congress* (Washington, D.C.: 1985)

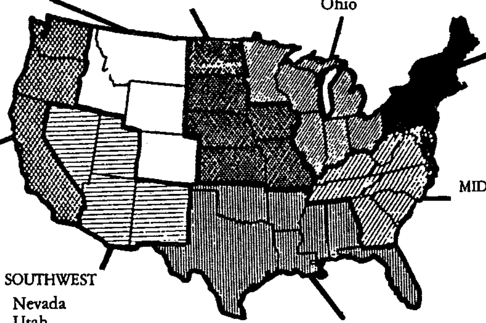
states and jurisdictions reported on the sources impeding designated uses in a total of 1,537,812 acres of lakes and reservoirs. As Table 2-11 shows, in these states, nonpoint sources are by far the leading cause of use impairment, affecting 51 percent of assessed lake acres. The only geographic region where nonpoint sources are not the leading degraders of lake quality is the Mid/South Atlantic, where municipal and industrial dischargers are the two leading polluters (Table 2-9). Municipal sources were reported to affect 32 percent of lake acres not supporting uses; industrial discharges follow as a cause of use impairment, and were reported in 10 percent of lake acres. Natural sources were reported as a cause of use impairment in 4 percent of lake acres, and the remaining 3 percent were affected by other or unknown sources. Combined sewer overflows were not specifically reported as a cause of use impairment in lakes.

The most widely reported problem impairing uses in the nation's lakes is eutrophication. Eutrophication is the "aging" of water bodies, primarily lakes and other standing waters, caused by excessive nutrient levels.

Although eutrophication is a natural process that occurs over long periods of time, in many cases, man's activities have accelerated the process. As

FIGURE 2-2

STATES IN GEOGRAPHIC REGIONS DEFINED FOR CLASSIFYING STREAMS AND LAKES



SOURCE: Environmental Protection Agency, *National Water Quality Inventory: 1984 Report to Congress* (Washington, D.C.: 1985).

Table 2-8. Geographic Summary of Designated Use Support for Streams

Geographic Area[1]	No. of States Reporting	Total Assessed Miles	Degree of Designated Use Support Designated Use Support Classification (Miles/Percent)				No. of States Reporting	Causes of Nonsupport Causes (Percent)					
			Fully Supporting	Partly Supporting	Not Supporting	Unknown		Municipal	Industrial	CSOs	Non-point	Natural	Other
Northeast	9	45,167	32,687(72)	3,102(7)	4,377(10)	5,001(11)	7	40	17	11	21	6	5
Mid/South Atlantic	8	86,010	62,424(72)	14,800(17)	5,675(7)	3,111(4)	8	30	17	0	35	1	17
Great Lakes	4	33,427	25,664(77)	6,341(19)	1,422(4)	0(0)	3	63	9	1	10	1	7
Central/ Gulf Coastal	5	63,031	52,436(83)	4,089(7)	3,228(5)	3,278(5)	3	47	24	0	29	0	0
Central Plains	6	49,699	23,914(48)	12,645(25)	1,562(3)	11,578(23)	5	29	2	0	54	2	13
Western Mountains	2	29,168	27,403(94)	1,105(4)	460(2)	200(1)	2	16	4	0	73	7	0
Southwest	2	5,079	4,298(85)	345(7)	431(8)	5(1)	1	34	0	0	21	0	45
Pacific Coast	2	11,809	8,147(69)	2,876(24)	786(7)	0(0)	2	19	8	0	60	10	3

[1]See Figure 2-2 for states located in each geographic area.

Source: U.S. Environmental Protection Agency, *National Water Quality Inventory: 1984 Report to Congress* (Washington, D.C.: 1985).

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Table 2-9. Geographic Summary of Designated Use Support for Lakes

			Degree of Designated Use Support Designated Use Support Classification (Acres/x000/Percent)					Causes of Nonsupport Causes (Percent)					
Geographic Area[1]	Total No. of States Reporting	Total Assessed (X000)	Fully Supporting	Partly Supporting	Not Supporting	Unknown	No. of States Reporting	Municipal	Industrial	CSOs	Non-point	Natural	Other
Northeast	7	1,818	1,587(87)	139(8)	93(5)	0(0)	3	9	1	0	70	17	3
Mid/South Atlantic	8	2,267	1,729(76)	378(17)	158(7)	1(0)	8	38	27	0	24	5	6
Great Lakes	3	1,126	843(75)	282(25)	1(0)	0(0)	2	11	5	0	84	0	0
Central/ Gulf Coastal	3	1,489	1,470(99)	19(1)	0(0)	0(0)	1	0	0	0	100	0	0
Central Plains	5	1,713	1,488(87)	144(8)	0(0)	80(5)	2	1	0	0	99	0	0
Western Mountains	0	-	-	-	-	-	0	-	-	-	-	-	-
Southwest	1	99	82(83)	6(6)	11(11)	0(0)	0	-	-	-	-	-	-
Pacific Coast	2	1,059	242(23)	552(52)	264(25)	0(0)	2	33	0	0	62	5	0

[1]See Figure 2-2 for states located in each geographic region.

Source: U.S. Environmental Protection Agency, *National Water Quality Inventory: 1984 Report to Congress* (Washington, D.C.: 1985).

Table 2-10. Causes of Stream Miles Not Fully Supporting Designated Uses

Cause	Percent
All Point	48
Municipal	36
Industry	11
Combined Sewer Overflows	1
Nonpoint	39
Natural	2
Other	11
Total	100

Source: U.S. Environmental Protection Agency, *National Water Quality Inventory: 1984 Report to Congress* (Washington, D.C.: 1985).

Table 2-11. Causes of Lake Acres Not Fully Supporting Designated Uses

Cause	Percent
All Point	42
Municipal	32
Industry	10
Combined Sewer Overflows	0
Nonpoint	51
Natural	4
Other	3
Total	100

Source: U.S. Environmental Protection Agency, *National Water Quality Inventory: 1984 Report to Congress* (Washington, D.C.: 1985).

mentioned previously, nutrients enter lakes from a variety of sources; agricultural and rangeland runoff, leaking septic systems, and municipal waste water treatment facilities are leading sources. These high nutrient levels can stimulate the growth of algae masses and aquatic weeds, which, in turn, affect fish populations and recreational water uses.

Lakes can be classified according to their trophic status or level of eutrophication. *Oligotrophic* lakes are those "younger" lakes with low nutrient levels and resultant low productivity. *Eutrophic* lakes are highly productive and nutrient enriched, with high levels of organic matter in the water column and in sediment. *Mesotrophic* lakes are those in an intermediate stage between oligotrophy and eutrophy.

In 1984, 19 states provided information on the trophic status of their lakes and reservoirs. A total of 3,755 lakes were included in this assessment.

Thirty-six percent, or 1,358 lakes, were classified as eutrophic, 48 percent were classified as mesotrophic; and 14 percent were classified as oligotrophic. In the remaining 2 percent of lakes, trophic status was unknown.

National Fisheries Survey

The "1982 National Fisheries Survey"[5] is a statistical survey of fisheries conducted by EPA and the Fish and Wildlife Service. It concluded that the nation's waters, to a large degree, are able to support sport fish populations, and that this ability has not changed appreciably during the last five years.[6]

Capacity of Rivers and Streams to Support Fish: Sport fish species that are generally thought to be intolerant of poor water quality are widely distributed, occurring in an estimated 73 percent of the nation's waters. Anadromous sport fish species, such as salmon and steelhead trout, occur in 11 percent of the total stream miles. Commercial fish species occur in 17 percent of all waters, which indicates that fresh water commercial fish populations are an important part of the nation's overall aquatic resources. Nonsport fish species occur in 68 percent of the nation's waters, with nonsport anadromous species, such as shad, occurring in only 2 percent of the total stream miles. Sport fish are abundant in 23 percent and common in 41 percent of all waters. The majority (67 percent) of streams are at present suitable as sport fish habitats.

The two most prevalent sport fish species are the largemouth bass and the rainbow trout, which occur in 27.3 percent and 22.1 percent, respectively, of the nation's waters (see Table 2–12). The current distribution of these two species may be a result of intensive stocking efforts used in the past to broaden their ranges. However, stocking fish to enhance or maintain sport fish populations does not at present occur in many of the nation's waters. Less than 10 percent of the nation's streams are currently being stocked.

The common carp, an introduced species, is the most prevalent nonsport fish species. Carp occur in over 19 percent of the nation's waters, followed closely by a native species, the creek chub, which occurs in over 18 percent.

National Water Summary

The 1984 *National Water Summary* identified dissolved solids, phosphorus, and nitrogen as water-quality concerns.[7] When present in high concentrations, they can restrict water use for many purposes.

Dissolved Solids: The concentration of dissolved solids is used widely as a general indicator of water quality and of the suitability of water for various uses. High concentrations, for example, hamper municipal and industrial uses of water by increasing treatment costs, accelerating pipe corrosion, and increasing soap and detergent use. The EPA recommends that public water supplies contain no more than 500 milligrams per liter (mg/L) of dissolved solids.[8] High dissolved solids also detract from the value of water for irrigation at levels greater than about 700 mg/L,[9] although higher concentrations can be tolerated by some crops grown on permeable soils with careful water irrigation management.

Mean dissolved-solids concentrations at National Stream-Quality Accounting Network (NASQAN) stations vary widely, reflecting the broad range of natural and human influences on dissolved solids in different parts of the

Table 2-12. Ten Most Prevalent Sport and Nonsport Fish Species Occurring in the Nation's Waters

Species	Streams Miles	Streams Percentage[1] Occurrence
Sport Fish Species		
Largemouth bass	263,859	27.3
Rainbow trout	213,461	22.1
Bluegill	188,495	19.5
Channel catfish	148,343	15.4
Smallmouth bass	142,142	14.7
Green sunfish[2]	126,074	13.1
Brook trout	103,507	10.7
Black crappie	98,190	10.2
Spotted bass	98,129	10.2
Rock bass	94,682	9.8
Nonsport Fish Species		
Common carp	187,417	19.4
Creek chub	176,709	18.3
White sucker	166,823	17.3
Gizzard shad	131,730	13.6
Bluntnose minnow	126,665	13.1
Stone roller	122,337	12.7
Green sunfish[2]	115,234	11.9
Common shiner	112,112	11.6
Fathead minnow	110,531	11.4
Golden shiner	106,602	11.0

[1]Occurrences were not estimated separately for perennial streams.
[2]The green sunfish is considered to be both a sport and nonsport fish species under the Survey definition.

Source: U.S. Department of the Interior, Fish and Wildlife Service, 1982 *National Fisheries Survey Volume I Technical Report: Initial Findings* (Washington, D.C.: FWS/OBS-84/06, June 1984).

country. Mean concentrations at NASQAN stations range from 26.0 mg/L in the Saco River in Maine to 32,900 mg/L in the Salt Fork Brazos River in Texas. These extremes are indicative of the general pattern of higher concentrations west of the Mississippi River than to the east. Of the 71 stations with mean concentrations exceeding the drinking-water criterion of 500 mg/L, 68 are west of the Mississippi River. The western part of the country contains vast arid and semiarid areas that favor concentration of dissolved solids through evapotranspiration, a process further stimulated by extensive irrigation.

A large number of the nation's rivers showed significant change in dissolved solids during water years 1975 to 1981. Dissolved-solids concentrations increased at 59 percent of the stations that showed significant trends. Because the data were flow-adjusted before applying the trend tests, the effects of wet and dry years largely were eliminated as explanations for these trends; therefore, some

form of human activity is the probable cause of most of the trends. The geographic pattern of the trends and the location of irrigated farmlands suggest that irrigation return flows are important contributors of dissolved material to rivers, especially in semiarid basins of the West and Southwest.

Phosphorus: Phosphorus is an essential plant nutrient derived from natural and human-induced sources. Most phosphorus in rivers is either dissolved as phosphate ions and organic phosphorus molecules or suspended in association with inorganic suspended sediment and organic particulate matter, such as algae. Natural sources of phosphorus include dissolution of phosphorus-bearing rocks (abundant in some parts of the country, such as Florida), decay of organic plant material, animal wastes, and atmospheric deposition. Important human-induced sources are human wastes, synthetic detergents in sewage effluent, and runoff from feedlots and urban and fertilizer-rich agricultural areas.

The principal adverse effect of phosphorus on water quality is the stimulation of excessive growth of aquatic plants. Such growth may lead to murky water, floating algae, dense mats of rooted and floating aquatic plants, depletion of dissolved oxygen associated with decaying plant material, and associated damage to fisheries. Recreation may be hampered, and treatment costs may increase for municipal and industrial users. Such problems are more severe in lakes, reservoirs, and estuaries fed by rivers, rather than in the rivers themselves, where velocities of flow reduce the adverse effects.

Mean concentrations of total phosphorus at NASQAN stations vary widely across the country and generally are similar in pattern to suspended-sediment concentrations. In many rivers, most of the phosphorus is associated with fine-grained sediment, rather than with the dissolved state. Mean concentrations range from 0.015 mg/L in the Saco River in Maine to 5.7 mg/L in the Little Colorado River in Arizona. The general quality guidelines of 0.05 mg/L for rivers entering lakes or reservoirs is exceeded by mean concentrations at 223 stations, and the guideline of 0.10 mg/L is exceeded at 165 stations. The high frequency at which the quality guidelines are exceeded may be somewhat misleading because the majority of the phosphorus in these large rivers probably is bound tightly with sediment particles and not readily available to biota.

Total phosphorus concentrations at NASQAN stations for water years 1975 to 1981 show roughly equal numbers of increasing (49) and decreasing (43) trends in phosphorus nationwide; however, as with suspended-sediment concentrations, the trends are predominantly in one or the other direction in certain regions. In the Great Lakes and Upper Mississippi regions, phosphorus concentrations generally are declining, possibly as a result of major phosphorus-control efforts in those areas during the late 1970s.[10] In Florida, along the Gulf Coast, and in the Arkansas and Red River basins, phosphorus concentrations are mostly increasing. Many of the increases in the South are in agricultural areas and thus may result from increased agricultural activity and fertilizer use.

Inorganic Nitrogen: Like phosphorus, nitrogen also is a key plant nutrient. The primary forms of nitrogen in rivers are nitrate, nitrite, ammonia, and assorted organic compounds. This discussion focuses on inorganic nitrogen, which primarily consists of nitrate with lesser amounts of nitrite.

The principal natural sources of nitrogen are atmospheric deposition and soil nitrogen derived from the degradation of organic material and biological

fixation of nitrogen gas from the atmosphere. Human sources include sewage effluent and agricultural and urban runoff.

The potential water-quality effects of nitrate include stimulation of excessive plant growth and toxicity to human infants.[11] There are no water-quality criteria related to the role of nitrogen in stimulating plant growth. The human-health criterion for nitrate in drinking-water supplies is 10 mg/L as nitrogen.[12]

Nitrate concentrations follow a pattern that is distinctly different from that of dissolved solids and phosphorus. Many of the highest mean concentrations are in the Mississippi River and its tributaries, where discharge and transport are also high. Much of that area is farmed intensely, receives heavy nitrogen fertilizer applications, and produces large quantities of nitrogen-rich livestock wastes. Nationwide, mean nitrate concentrations range from 0.025 mg/L nitrogen in the Pend Oreille River in Washington to 9.8 mg/L nitrogen in the Gila River in Arizona. Mean nitrate concentrations did not exceed the human-health criterion of 10 mg/L at any station.

Inorganic nitrogen concentration at NASQAN stations from 1975 to 1981 shows a large number of increases nationwide, especially at stations in the eastern half of the country and in the Pacific Coast basins of the Northwest. Only scattered locations in the western half of the country, especially the Colorado River basin, show decreases.

GROUND WATER

Ground water is an increasingly important resource in the United States. It is relied upon for about 50 percent of drinking water supplies; it is used to supply water for almost 80 percent of rural domestic and livestock needs, about 40 percent of irrigation needs, many commercial activities, and almost 25 percent of self-supplied industrial needs (other than thermoelectric power); it is used for stream flow maintenance and as a barrier to saltwater intrusion; and it is both an intentional and unintentional depository for society's waste and nonwaste products.[13]

The degree of reliance on ground water varies significantly around the nation. For example, ground water withdrawals for public water supplies vary from 11 percent in the Great Lakes region to 75 percent in the Rio Grande region; for rural uses, from 12 percent in the Upper Colorado to 100 percent in New England; and for irrigation, 1 percent in the Upper Colorado to over 90 percent in the Upper Mississippi.[14]

Contamination of ground water—by organic and inorganic chemicals, radionuclides, and/or microorganisms—has occurred in every state and is being detected with increasing frequency.[15] For a long time, the land surface and subsurface were considered safe and convenient depositories for many of society's waste and nonwaste products. Only recently have limitations in the capacity of natural soil processes to change contaminants into harmless substances before they reach ground water been recognized.

This section reports on the nature of ground water, and on the extent, sources, and impacts of contamination. This analysis relies heavily on EPA's "Ground-Water Protection Strategy"[16] on the nature of ground water contamination; and the Office of Technology Assessment's (OTA) report, "Protecting the Nation's Groundwater From Contamination",[17] on the extent, sources, and impacts of contamination.

Programs and efforts aimed towards ground water protection are discussed in the subsequent issues section.

The Nature of Ground Water

Ground water, a vast resource underlying all of our land, occurs in aquifers beneath the surface of the earth. Aquifers are geologic formations that contain enough water in a sufficiently permeable setting to yield usable amounts of water to wells and springs. The scale of aquifers and the geological and geochemical factors that influence the movement and changes in water passing through them make ground water a very complex resource to understand.

Usable aquifers are present nearly everywhere in the United States. The volume of known ground water is about 50 times greater than annual surface flow in the entire nation. Another way to conceptualize the immense size of this resource is to consider that the volume of ground water to be found within one-half mile of the surface is estimated to be more than four times that of the Great Lakes.

In general, the degree to which people use ground water depends on a number of factors, one of which is whether good quality surface water is available. Another factor is the relative cost of delivering the ground water to individual users.

Ground water is the source of a substantial share (24 percent) of the nation's domestic, agricultural, and industrial water. Between 1950 and 1980, total ground water withdrawals increased from 34 to 89 billion gallons per day (BGD), an increase of 162 percent. The 1980 figure represents 24 percent of all the fresh water used (372 BGD) that year. Further, ground water withdrawals are projected to reach 100 BGD by 1985. The principal uses of ground water in 1980 were for irrigation (60 BGD), public drinking water (12 BGD), with smaller amounts applied to industrial and rural household use.[18]

Reliance on ground water has increased greatly over the past 35 years. In some parts of the country ground water is often the only available source of drinking water and can generally be used with little or no treatment.

Once contaminated, ground water presents particularly difficult problems for monitoring and cleanup, principally because it is not accessible directly. Moreover, monitoring of ground water is very expensive, particularly where depths are substantial and multiple test wells must be drilled. Restoration after contamination is often complex and expensive, and success is unpredictable. For example, in the case of a gasoline spill, where the contaminant is valuable, recovery operations are typically 40–60 percent effective at best. In most circumstances, therefore, it is prudent to protect the resource from contamination, rather than to rely on cleanup after the fact.

Ground water contamination is of particular concern because of its potential impact on sources of drinking water. Over 50 percent of the U.S. population draws upon ground water for its potable water supply. Approximately 117 million people in the U.S. get their drinking water from ground water supplied by 48,000 community public water systems and approximately 12 million individual wells. The remaining people get their drinking water from 11,000 public water systems drawing from surface water sources. About 95 percent of rural households depend on ground water, as does a still larger proportion

(97 percent) of 165,000 noncommunity public water supplies (such as camps or restaurants serving a transient population). Finally, 34 of the 100 largest U.S. cities rely completely or partially on ground water.[19]

Until recently, the public viewed drinking water drawn from the ground as a pristine resource, unspoiled by human activities. Most believed that soils were capable of binding and holding chemicals applied to their surfaces. While this is true for some chemicals, we have learned over the past few years that it is definitely not true for several important and widely used classes of chemicals, such as low molecular-weight organic solvents. Among those of primary concern are such common chemical solvents as tri- and tetrachloroethylene, benzene, and chlorinated benzenes.

This new understanding of the vulnerability of ground water to contamination by manmade chemicals is significant. Where concentrations of these substances have been encountered in ground water, they have been in orders of magnitude higher than those generally found in surface water. This is particularly disturbing because, while about half of water systems drawing from ground water provide chlorination treatment, this remedy is ineffective for chemical contaminants.[20] Many of the most troublesome chemicals are toxic, and some have been linked to cancer in test animals. For example, the suspected carcinogen, trichloroethylene (TCE), has been found—if only rarely—at levels as high as 500,000 parts per billion (ppb) in heavily contaminated ground water. Typical concentrations in ground water are significantly less than 100 ppb. EPA's health advisory on TCE, based on toxic effects, recommends safe levels of TCE in drinking water at 2,000 ppb for an exposure duration of one day, and at 80 ppb for a duration of one to two years. The companion guidance on cancer risks projects excess risk due to drinking water contaminated by TCE to be one in a million at a lifetime exposure level of 2.8 ppb.[21] The Agency is also proposing drinking water regulations that include TCE as one substance to be controlled.

Ground Water Contamination

A small amount of the nation's ground water is generally believed to be contaminated; estimates have ranged from about one to two percent.[22] Although this portion may seem very small, it is significant because contamination is often near heavily populated areas where ground water is being increasingly relied on for a variety of uses. Incidents of contamination are being reported with increasing frequency and have now occurred in every state. Although the activities and practices that cause contamination are varied and were often begun many years ago, ground water contamination recently has come to the attention of the public, primarily in the context of threats to human health. Most of the attention had focused on sources associated with hazardous wastes (e.g., landfills, surface impoundments, and waste piles) because of the severity of their impacts on surrounding populations and environments—and ground water has been seriously contaminated by toxic chemicals associated with these sources in at least 34 states.[23] However, nonhazardous wastes and nonwastes also contribute to the contamination of ground water.

A complete description of contamination would require detailed information about ground water quality on a site-by-site basis throughout the nation

and about associated site-specific hydrogeologic conditions (e.g., the vulnerability of ground water to the entrance of substances). A difficulty in assessing the extent of ground water contamination is that not all substances entering ground water may have adverse impacts. Whether the presence of substances in ground water results in a contamination problem depends on site-specific hydrogeology, the potential for adverse impacts (health, economic, environmental, and social), current and future ground water use patterns, the exposure of humans to the substances, the availability of alternative water supplies, and the feasibility of corrective measures, including management alternatives.

Sources of Contamination

The quality of ground water is altered by a wide variety of human activities and naturally occurring situations. Sources are points where the substances can be released into ground water along the pathways that substances travel as they flow through society.[24] To illustrate, substances can be stored in or flow through sources in a variety of ways, from the storage of raw materials (e.g., materials stockpiles), to manufacturing (e.g., product storage), to distribution (e.g., pipelines), to use (e.g., pesticide applications), to disposal (which can take place almost anywhere in the process).

OTA identified 33 sources known to have contaminated ground water and categorized them based on the nature of their release of substances to ground water (Table 2–13). Figure 2–3 illustrates these pathways of contamination. Three general conclusions can be reached from this categorization:

1. There is a great diversity of sources, and they are associated with a broad range of industrial, agricultural, commercial, and domestic activities. Both wastes and nonwastes are potential contaminants of ground water. However, most attention has been focused on wastes, particularly hazardous wastes, from point sources or clusters of point sources. (A "point" source is an easily identified facility, such as a landfill or impoundment.)
2. Only a few source types (Category I) are specifically designed to discharge substances (i.e., wastes) into the subsurface.
3. Nonwaste releases result from some sources designed to retain nonwaste products (Categories II and III) and as a consequence of other activities (Category IV) or altered flow patterns (Category V).

Current estimates of the number of sources and the amounts of materials flowing through or stored in these sources are presented in Table 2–14. At least four limitations are inherent in these estimates:

1. The estimates are specifically for the amounts of material flowing through or stored in the source and are not estimates of the amounts of material actually reaching the ground water (unless otherwise indicated). Thus the estimates suggest only the maximum potential for ground water contamination.
2. An estimate of the amount reveals nothing about the nature and concentration of substances in that material. Industrial and municipal sludge provides an example. The amount of industrial sludge used in land applications is roughly 7 percent of that used from municipal systems, yet often the chemical compounds or their concentrations in industrial sludge (e.g., inorganic acids and higher concentrations of hydrocarbons) pose

Table 2-13. Sources of Ground Water Contamination

Category I—Sources designed to discharge substances

- Subsurface percolation (e.g., septic tanks and cesspools)
- Injection wells
  - Hazardous waste
  - Non-hazardous waste (e.g., brine disposal and drainage)
  - Non-waste (e.g., enhanced recovery, artificial recharge, solution mining, and in-situ mining)
- Land application
  - Wastewater (e.g., spray irrigation)
  - Wastewater byproducts (e.g., sludge)
  - Hazardous waste
  - Non-hazardous waste

Category II—Sources designed to store, treat, and/or dispose of substances; discharge through unplanned release

- Landfills
  - Industrial hazardous waste
  - Industrial non-hazardous waste
  - Municipal sanitary
- Open dumps, including illegal dumping (waste)
- Residential (or local) disposal (waste)
- Surface impoundments
  - Hazardous waste
  - Non-hazardous waste
- Waste tailings
- Waste piles
  - Hazardous waste
  - Non-hazardous waste
- Materials stockpiles (non-waste)
- Graveyards
- Animal burial
- Aboveground storage tanks
  - Hazardous waste
  - Non-hazardous waste
  - Non-waste
- Underground storage tanks
  - Hazardous waste
  - Non-hazardous waste
  - Non-waste
- Containers
  - Hazardous waste
  - Non-hazardous waste
  - Non-waste
- Open burning and detonation sites
- Radioactive disposal sites

Category III—Sources designed to retain substances during transport or transmission

- Pipelines
  - Hazardous waste
  - Non-hazardous waste
  - Non-waste
- Materials transport and transfer operations
  - Hazardous waste
  - Non-hazardous waste
  - Non-waste

Category IV—Sources discharging substances as consequence of other planned activities

- Irrigation practices (e.g., return flow)
- Pesticide applications
- Fertilizer applications
- Animal feeding operations
- De-icing salts applications
- Urban runoff
- Percolation of atmospheric pollutants
- Mining and mine drainage
  - Surface mine-related
  - Underground mine-related

Category V—Sources providing conduit or inducing discharge through altered flow patterns

- Production wells
  - Oil (and gas) wells
  - Geothermal and heat recovery wells
  - Water supply wells
- Other wells (non-waste)
  - Monitoring wells
  - Exploration wells
- Construction excavation

Table 2-13. Sources of Ground Water Contamination—Continued

Category VI—Naturally occurring sources whose discharge is created and/or exacerbated by human activity	Natural leaching Salt-water intrusion/brackish water upconing (or intrusion of other poor-quality natural water)
Groundwater—surface water interactions	

Source: Office of Technology Assessment, *Protecting the Nation's Groundwater From Contamination* (Washington, D.C.: OTA-0-233, October 1984).

greater health threats than the chemical compounds found in municipal sludge.

3. Accuracy of the quantitative estimates varies considerably from source to source, depending on the underlying assumptions and completeness of the data. This study attempted to address this problem by indicating the range of values within which the true value probably falls, but even this approach is arbitrary. It is important to remember that there is a high degree of uncertainty underlying the estimates and that they are best used to indicate the most numerous and most material-intensive sources.
4. Comparing estimates is difficult because they are expressed in different units of measurement. The units cannot be converted into a common base unit; thus only simple categorizations of large versus small numbers or amounts can be made.

Given these caveats, Table 2-14 is still useful in at least two ways:

1. It indicates sources that are numerous and/or have large amounts of associated materials.
2. It shows that nonpoint sources (e.g., Category IV, including fertilizer and pesticide applications) and sources dealing with nonwaste products (e.g., Category II, including underground storage tanks) and with nonhazardous wastes (e.g., Category I, including brine disposal wells) are often as important in terms of numbers or amounts of material as point sources or hazardous waste sources. Many of the nonpoint sources have associated with them chemicals that are highly toxic (e.g., pesticide applications) or very diverse (e.g., underground storage tanks).

Impacts of Contamination

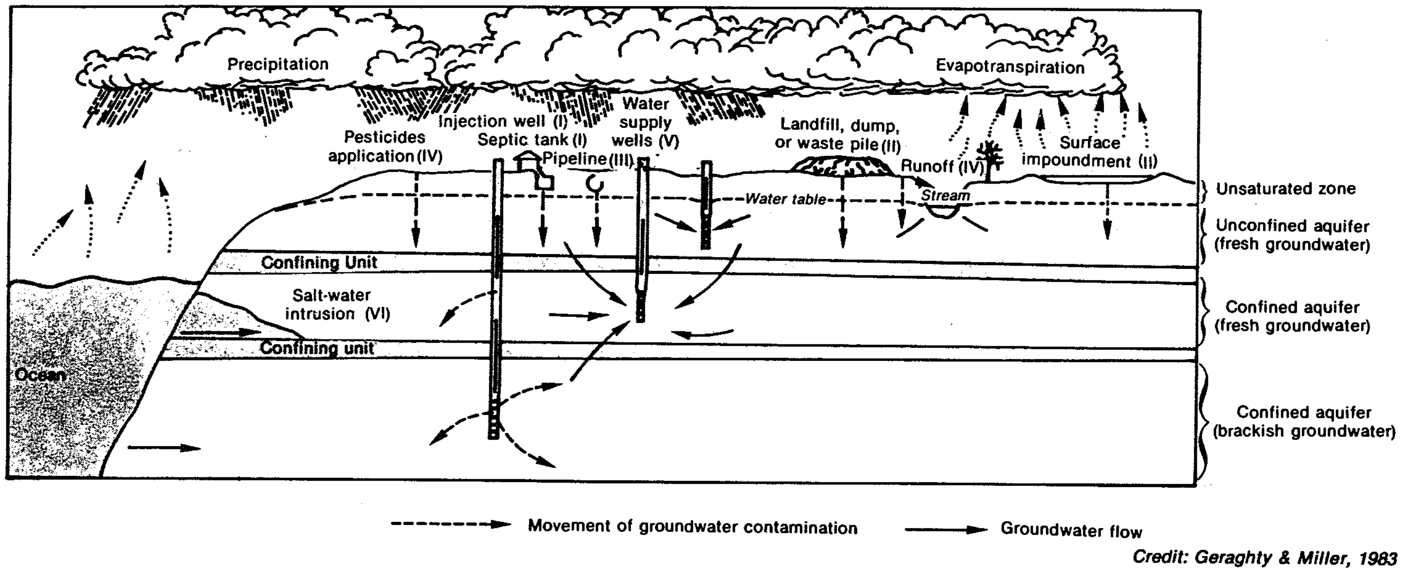
Contaminants found in ground water—particularly organic chemicals—are associated with adverse health, social, environmental, and economic impacts. Although only a small portion of the nation's total ground water resource is thought to be contaminated, such contaminated ground water is often located near industrialized, heavily populated areas, which increases the likelihood of human exposure.

Health effects of chemicals are of great concern because chemicals are pervasive and may persist in the environment.

Assessing risks from substances in ground water requires information about adverse effects, toxicity, and exposure; and available data are often insufficient

FIGURE 2-3

PATHWAYS OF GROUNDWATER CONTAMINATION



Pathways of groundwater contamination vary depending on the source. Examples of sources are shown here for each of the six source categories (I-VI) mentioned.

SOURCE: Congress of the United States, Office of Technology Assessment, *Protecting the Nation's Groundwater from Contamination: Volume I,* Washington, D.C.: OTA-0-233, October 1984, p.21.

Table 2-14. Numbers of Sources and Amounts of Material Flowing Through or Stored in Sources[1]

Source	OTA Update			1977 Report	
	Approximate number of facilities	Approximate amount of material[2]	Possible Uncertainty in number estimate[3]	Possible Uncertainty in amount estimate[3]	Approximate amount of material
Category I					
Subsurface percolation					
Domestic	16.6–19.5 million	820–1,460 bgy	<2x	<2x	800 bgy
Industrial ...	25,000	1–2 bgy	>10x	>10x	1.2 bgy
Injection wells					
Hazardous waste	87	8.6 bg[4]	<10x	<10x	---
Drainage, etc.	350,000	?	<10x	?	---
Brine.	525 bgy	<10x	<10x	460 bgy	
Non-waste (enchanced oil recovery)	140,000	24.5 bgy	?	<10x	---
Non-waste (solution, in-situ)	12,000	?	?	<10x	0.3 mty
Land application					
Municipal slude	2,500	3–4 mty (dry)	<10x	<10x	4 mty
Industrial hazardous waste	70	0.10 bgy[4]	<10x	<10x	---
Spray irriga-tion	485	?	>10x	?	---
Category II					
Landfills					
Industrial hazardous waste	199	0.81 bgy[4]	<10x	>10x	50 bgy
Industrial non-hazard-ous waste ..	75,700	40–140 mty (wet)	<10x	>10x	
Utility	?	30 mty (wet)	?	>10x	---
Municipal ...	15–20,000	138 mty	<2x	<2x	90 bgy
Open dumps ..	2,400	10 bgy	>10x	>10x	---
Residential disposal sites	?	?	?	?	---
Surface impoundments					
Hazardous waste	1,078	35.8 bgy[4]	<10x	<10x	---
Non-hazard-ous waste ..	180,000	1,800 bgy[5]	<2x	<10x	161 bgy
Waste tailings ..	?	580 mty	?	<2x	---
Waste piles					
Hazardous waste	174	0.4 bgy	>10x	>10x	---
Non-hazard-ous waste ..	?	1,730 mty	?	<2x	---

Table 2-14. Numbers of Sources and Amounts of Material Flowing Through or Stored in Sources[1]—Continued

	OTA Update			1977 Report	
Source	Approximate number of facilities	Approximate amount of material[2]	Possible Uncertainty in number estimate[3]	Possible Uncertainty in amount estimate[3]	Approximate amount of material
Category II—Continued					
Materials stockpiles ...	?	700 mty	?	<10x	---
Graveyards	?	?	?	?	---
Animal burial ..	?	?	?	?	---
Aboveground storage tanks	?	?	?	?	---
Underground storage tanks					
Hazardous waste	2,031	13.8 bgy	<10x	<10x	---
Non-hazardous waste	2.5 million	25 bg	<2x	<10x	---
Non-waste ...	?	?	?	?	---
Containers					
Hazardous waste	3,577	0.16 bgy[4]	<10x	<10x	---
Non-hazardous waste	?	?	?	?	---
Non-waste ...	?	?	?	?	---
Open burning and detonation sites ...	?	?	?	?	---
Radioactive disposal sites	31[6]	3.7 million	<2x	<2x	---
Category III					
Pipelines					
Hazardous waste	?	?	?	?	---
Non-hazardous waste	700,000	280 bgy	<10x	>10x	250 bgy
Non-waste ...	175,000	10 billion	?	?	---
Materials transport and transfer operations					
Hazardous waste	16,000	14 mty	<10x	>10x	---
Non-hazardous waste	spills				
Non-waste ...	?	?	?	?	---
Category IV					
Irrigation practices	50–60 million acres	169 million acre-feet	<2x	<2x	---
Pesticide applications	280 million acre-treatments	0.26 mty active ingredients	<2x	<2x	---
Fertilizer applications	229 million acre-treatments	42 mty	<2x	<2x	---

Table 2-14. Numbers of Sources and Amounts of Material Flowing Through or Stored in Sources[1]—Continued

Source	OTA Update: Approximate number of facilities	OTA Update: Approximate amount of material[2]	OTA Update: Possible Uncertainty in number estimate[3]	1977 Report: Possible Uncertainty in amount estimate[3]	1977 Report: Approximate amount of material
Category IV—Continued					
Animal feeding operations ..	1,935	8 mty	<2x	<10x	---
De-icing salts applications ...	?	10–12 mty	?	<2x	---
Urban runoff .. million acres	21.2–32.6				
Percolation of atmospheric pollutants ..	NA	?	?	?	---
Mining and Mine drainage					
Surface	15,000 active	4 million acres	<10x	<10x	108 billion gallons
Underground	67,000 inactive	0.36–1.0 mty acid			
Category V					
Production wells					
Oil wells	548,000 activity 2 million abandoned	g	<10x	<10x	---
Geothermal, heat recovery	32	?	?	?	---
water supply .	350,000	?	?	?	---
Other wells (non-waste)					
Monitoring ..	?	?	?	?	---
Exploration ..	?	?	?	?	---
Construction excavation	?	45 mty	?	>10x	---
Category VI					
Ground-water surface water interactions .	NA	?	NA	?	---
Natural leaching	NA	?	NA	?	---
Salt-water intrusion	NA	?	NA	?	---

[1]? = OTA unable to obtain sufficient information to develop estimate.
--- = No estimate presented in 1977 report (EPA 1977).
NA = Not applicable.
[2]mty = million tons per year.
bgy = billion gallons per yar.
bg = billoin gallons per year.
[3]Confidence in estimates is defined as follows:
<2x = estimate considered correct within 100%.
<10x = estimate considered correct within one order of magnitude.
>10x = estimate *could* be incorrect by more than one order of magnitude
[4]Note that this figure refers to hazardous wastes regulated under RCRA.
[5]Estimate of actual amount of leachate.
[6]Excluses nuclear reactors.

Source: Office of Technology Assessment, *Protecting the Nation's Groundwater From Contamination* (Washington, D.C.: OTA-0-233, October 1984)

to conduct such an assessment. Thus human health impairment is not easily linked to substances found in ground water. Except for drinking water containing known levels of substances, there appear to be no general models available for estimating exposure through these routes.

Many of the chemicals detected in ground water are known or suspected to cause a variety of adverse health effects, including depression of central nervous system functions, liver and kidney damage, and eye and skin irritation. Some of these chemicals are known or suspected human carcinogens. The effects associated with the largest numbers of chemicals include (in decreasing order of the number of chemicals known to cause these effects): eye and skin irritation, effects on the central nervous system, liver damage, lung and respiratory tract effects, kidney damage, cancers, and genetic mutation.[25]

Data about various types of *economic impacts* associated with ground water contamination are generally not available.[26] The data that are available tend to be the direct costs of corrective action; and they either encompass such a broad range that they are difficult to interpret apart from site-specific conditions, or they lack sufficient documentation for subsequent comparison and analysis. Some data may also be unobtainable because of their proprietary nature or use in litigation.

In addition to empirical difficulties, there are also methodological difficulties in assessing the value of ground water quality in terms of both the costs of contamination and the benefits of protection. Few studies are available that systematically approach an assessment of economic impacts.[27]

The economic damages resulting from ground water contamination shown in Table 2–15 illustrate the types and magnitude of documented costs.

Contaminated ground water causes diverse *environmental and social impacts*; however, these impacts are generally not quantifiable and little documentation is available.

Because ground water provides a significant portion of baseflow to streams, the potential for adverse impacts on surface water quality may be large, especially during periods of low rainfall when dilution is minimal. Changes in the quantity of ground water also influence the quality of ground water (e.g., the pumping of ground water can induce the migration of contaminants). The extent of other environmental impacts is unknown; some cases document damage to fish, vegetation, and wildlife.[28] The potential for ground water contaminants (e.g., volatile organics) to enter the atmosphere in the vicinity of certain sources (e.g., landfills) or from volatilization during showering has now been recognized.[29]

Social impacts may arise from decreased property values, and from lost income because of illness, relocation, and inconvenience (e.g., in procuring alternative water supplies).[30]

MARINE AND ESTUARINE WATERS

Coastal and marine environments receive a variety of contaminants from multiple sources, including runoff from the land via streams and rivers, atmospheric fallout, point source discharges into the coastal zone, ocean dumping of dredged materials and other wastes, operational discharges from ships and offshore platforms, and accidental spills. While many of these

Table 2-15. Examples of Economic Costs Resulting From Contaminated Groundwater[1]

Location	Contaminants	Nature of costs	Direct costs incurred[2]	Documentation
Canton, CT	Carbon tetrachloride, methylethylketone, trichloroethythene chloroform	Well closings; extension of water lines to affected areas	$145,000–379,000	CRS, 1980a
Oscoda, MI	Trichloroethylene	Well closings; provision of new source of water	$140,000	CRS, 1980a
South Brunswick, NJ	Chloroform, toluene, xylene, trichloroethane, trichloroethylene	Well closings, extension of municipal water lines to affected area	$300,000	CRS, 1980a
Cohansey Aquifer, NJ	Wastes from manufacture of organic chemi-	Well closings (148); removal of drms; interim emergency water supply (via tanker trucks); drilling of new wells; extension of public water supply (60% of total monetary costs)	$417,000 (Residential cost of water increased water increased from an average of $45/year to $75/year)	U.S. EPA, 1976 CRS, 1980b
Miller County, AR	Brine contamination from oil and gas activities	Loss of irrigation well Partial rice crop loss Estimated loss in profits for changing from irrigated to non irrigated crops	$4,000 $36,000 $150/acre/year for rice $35/acre/year for cotton $20/acre/year for soybeans	Fryberger, 1972
38 communities in 11 Midwestern States[3]	Mineral content	Reduced service lives of household plumbing and appliances	Increased annual capital cost per household of 40% as total dissolved solids increase from 250 ppm to 1,750 ppm	Patterson, et al., 1968
Atlantic City, NJ	Chemical wastes	Estimated cost of new well field to replace contaminated wells Cost of alternative water supply to 35 private residences	$2 million $250,000	As reported in Sharefkin, et al, 1983

See footnotes at end of table

Table 2-15. Examples of Economic Costs Resulting From Contaminated Groundwater[1]—Continued

Location	Contaminants	Nature of costs	Direct costs incurred[2]	Documentation
Orange County, CA[4]	Mineral content	Estimated cost of reduced service lives of household plumbing and appliances Estimated average annual cost of water softeners or increased cost of cleaning products Estimated average costs of using bottled water	$6.5 million total annual capital cost $12.3 million $2.2 million	Orange County Water District, 1982
Montanta	Salinity	Loss of farm income	$5 million per year	Miller, 1980
San Joaquin Valley, CA	Salinity	Loss of farm income	$31.2 million per year	Sheridan, 1981
Auburn, MA	Unspecified chemicals	Alternative water supply for affected area	$180,000	U.S. House of Representatives, 1980
Lathrop, CA	Pesticides	Purchase of water by residents Connection to district water supply	$3–5 per 5 gallons $150 per connection, monthly operating costs of $4–10	CRS, 1980b
Jackson Township, NJ	Chloroform, methyl chloride, benzene toluene, trichloro-ethylene, ethyl-benzene, acetone	Costs of planned water system to replace closing of 100 wells	$1.2 million	CRS, 1980a

[1]Based on University of Oklahoma, 1983.
[2]Costs shown are not comparable because they are not measured in constant dollars.
[3]Almost all these communities obtain their primary water supply from groundwater.
[4]Costs are those associated with using higher salinity (surface) water from the Colorado River as opposed to water from the State Water Project.

Source: Office of Technology Assessment

contaminant inputs result from human activities in the coastal zone, others are derived from sources far removed from the marine environment. Some contaminants persist in the environment for long periods, and are relocated through the action of currents, sediment deposition, and resuspension. Because of the multiple sources and the complicated dynamics of mixing and remixing through time, management of estuarine and coastal contamination is not an easy matter. Effective control of coastal point-source discharges may reduce but would not eliminate coastal contamination.

Interpreting and understanding the effects of coastal contaminants are also very difficult, because organisms and ecosystems are subject to stress and modification from noncontaminant-related origins, including changes in climate or local meteorological conditions, predation (overfishing), food supply, and physical habitat modification. Habitat modifications include damming or diversion of rivers, which may affect fish migration routes or access to spawning or nursery grounds; and the draining, dredging, and filling of marshlands or shallow submerged habitats, which may eliminate protective cover or modify the normal food supplies of resident estuarine organisms.

Because of the complex functional dependencies among different organisms and their ecosystems, and because of the natural variability of marine systems, it is difficult to assess the significance of marine pollution problems from simple measurements of water quality. Pollution problems may go unrecognized until they have become severe. As a result of these considerations long-term data and information on marine environmental quality are generally unavailable, except for a few locations, usually those with high population densities, where problems were either suspected or already evident, or where recurring studies have occurred mainly as a result of proximity to active research facilities. And for the reasons mentioned above, the relationships between environmental quality measurements and possible biological or ecological effects are often unclear, even in the most heavily studied areas. The probable effects of contaminants in the marine environment must often be deduced from related experimental results from controlled conditions of exposure in the laboratory.

The Northeast Monitoring Program

Since 1980, the National Oceanic and Atmospheric Administration (NOAA) has conducted the Northeast Monitoring Program (NEMP) in coastal and estuarine areas from Maine to North Carolina. A coordinated program of measurements focuses on the distribution and trends in water and sediment quality, biological characteristics, and contaminants throughout the geographic area.[31] As part of this program, microorganisms have been monitored at the Philadelphia sewage sludge dumpsite (about 40 nautical miles east of the Delaware-Maryland border), both before and after dumping stopped there in November 1980. Cooperative annual surveys with the EPA and the Food and Drug Administration (FDA) have shown that by June 1983, sediments in and near the dumpsite either were negative for sewage-associated bacteria, or had densities within acceptable limits for shellfish harvesting. The potentially pathogenic protozoan, Acanthamoeba, was found in sediments at 35 percent of 23 stations sampled during the last summer of dumping, but its frequency of occurrence had dropped to 6 percent by summer 1983, and no specimens

were detected in summer 1984. Based on the bacterial and Acanthamoeba data, pathogens no longer present a significant health threat at the site, and FDA has recommended that the site can be reopened to shellfishing. Similarly, the prevalence of gill darkening in rock crabs from the Philadelphia dumpsite has declined progressively from about 17 percent in 1980 to zero in 1984. In contrast the prevalence of black gills in crabs from the deep waters of the Hudson Shelf Valley (near the active sludge disposal site in the New York Bight) has remained consistently high (6 percent–19 percent) since 1981. The findings from the Philadelphia site suggest that if similar quantities of sludge were dumped at other sandy midshelf sites, recovery could be expected within three years after disposal ceased.

NEMP has been monitoring bottom-dwelling invertebrate communities at 25 sites on the northeast shelf at least twice a year for the past six years. Earlier data are also available for some of the stations; for example, the baselines for the Buzzards Bay station extend back to 1955. Several stations have been selected for this program as "early warning" stations, because of their tendencies to accumulate fine sediments and, therefore, sediment-associated contaminants. Such stations are located: (1) in the mid-Hudson Shelf Valley, considered to be just beyond the seaward limit of contaminant effects in the New York Bight Apex, based on the "pristine" amphipod-dominated benthos present; (2) off Fire Island, Long Island, a sandy "control" station for the more contaminated inner Bight; (3) in the "Mud Patch," south of Nantucket, one of the few muddy depositional areas on the Middle Atlantic shelf and thus a candidate for early contaminant accumulation and effects; (4) in a depression just east of Long Island Sound where contaminants from nearby estuaries might be expected to accumulate; and (5) in the Baltimore Canyon Trough, an oil exploration area about 60 nautical miles east of southern New Jersey.

Mean numbers of benthic species generally and of amphipods in particular have been stable at these offshore monitoring stations over the periods for which data are available (1973–1984, for some stations). Although contaminant buildup and effects have long been documented in the Bight Apex,[32] no offshore spread of these effects has been detected. There has also been no tendency for the fauna of the "control" sites to become more like that of the contaminated areas over the six years of sampling. Two of the NEMP sites on southern Georges Bank also represent offshore areas that could potentially be impacted by recent or ongoing oil-related activities. No effects of such activities have been evident.

While the deeper portions of the inner New York Bight generally exhibit higher levels of contamination in sediments, the benthic biomass and production in these areas are still relatively high. Biomass values from 1973 and 1980 (127–344 g/m^2 wet weight) are equal to or greater than those reported for most presumably uncontaminated North Atlantic coastal and shelf areas.

Preliminary results show that several of the benthic species in the inner bight with high biomass are also common in the diets of demersal fish. For example, stomach contents of winter flounder examined in 1982–1983 were dominated by two species of polychaete worms and tentacles of burrowing anemones. These species are very abundant over much of the Christiaensen Basin and upper Hudson Shelf Valley, areas where sediment contaminants are also elevated. The potential for transfer of contaminants through the forage species to flounder

is clearly present. Winter flounder contained generally higher levels of polychlorinated biphenyls (PCBs) than other fish from the lower Hudson-Raritan estuary. Winter flounder, followed closely by American eel, exhibited concentrations as high as 10 percent of the FDA cautionary limit of 2 parts per million (ppm). Ongoing work in the NEMP will determine contaminant levels in the forage species from these areas, and attempt to clarify the pathways of contaminant transfer.[33]

Chesapeake Bay

The Chesapeake Bay is the nation's largest estuary and one of its most valuable natural resources. The Bay represents an abundant fishery and wildlife habitat of national importance; the annual harvest of finfish and shellfish has a commercial value of approximately $1 billion. The extensive shoreline and wetlands of the Bay provide a home for countless animals and plants, and are a major stop along the Atlantic Migratory Bird Flyway.

The Chesapeake Bay is also a major commercial shipping center with two major port complexes serving extensive transportation networks to inland areas. This network has encouraged development of other commercial activities in the region, such as fishing, shipbuilding, agriculture, steelmaking, paper manufacturing, and chemical production. In turn, these activities have attracted more people to the area as residents and as tourists who support the Bay's recreational industries.

The cumulative effects of these commercial and recreational activities are resulting in a decline in the living resources of the Bay. In response to this growing threat, the federal government and the states of the Chesapeake Bay region, under the Chesapeake Bay Agreement of 1983, have pledged to restore and protect the Chesapeake Bay and its living resources. A plan is now being developed for an integrated and comprehensive federal/state effort to restore and protect the Bay.[34]

In 1975, the U.S. Congress authorized the EPA to conduct a major study of the Bay's water quality and living resources. The EPA Chesapeake Bay Program identified or confirmed a number of environmental problems that represent a threat to the health and productivity of this estuary.

Increasing levels of nutrients are entering the Bay system, both from point sources (primarily sewage treatment facilities) and from nonpoint sources, especially runoff from agricultural lands, and in some places, inflows from urban areas. This process of eutrophication has resulted in increasingly frequent phytoplankton blooms, particularly in the upper Bay and the upper reaches of major tributaries. Increased algal density and increased sediment loads delivered to the Bay have reduced water clarity in many areas of the Chesapeake. This turbidity contributes to the unprecedented losses of submerged aquatic vegetation.[35] This submerged vegetation is important as forage for over-wintering waterfowl, and provides spawning areas and shelter for estuarine-dependent fishes, including striped bass, shad, and herring. The degradation of this ecological habitat helps explain the recent decrease of freshwater-spawning finfish landings. Another possible explanation for the reduction in fish productivity involves the documented decrease in dissolved oxygen levels found in parts of the Bay. Increased organics loadings resulting from eutrophication,

however, appear to be the primary cause of episodes of aquatic hypoxia and anoxia.

Elevated levels of heavy metals and toxic organic compounds are found in the sediments of industrialized areas and in the upper Bay. Benthic organisms exhibit lower diversities and abundances in these areas. Another problem is the reduction of the volume of freshwater flowing into the Bay due to increased domestic and industrial consumption. This reduction could have adverse impacts on a number of living resources, especially on those species that spawn or live in freshwater or are vulnerable to predators and parasites tolerant to higher salinities.

Sources of Pollutants in Two Coastal Systems: Southern California Bight and New York Bight

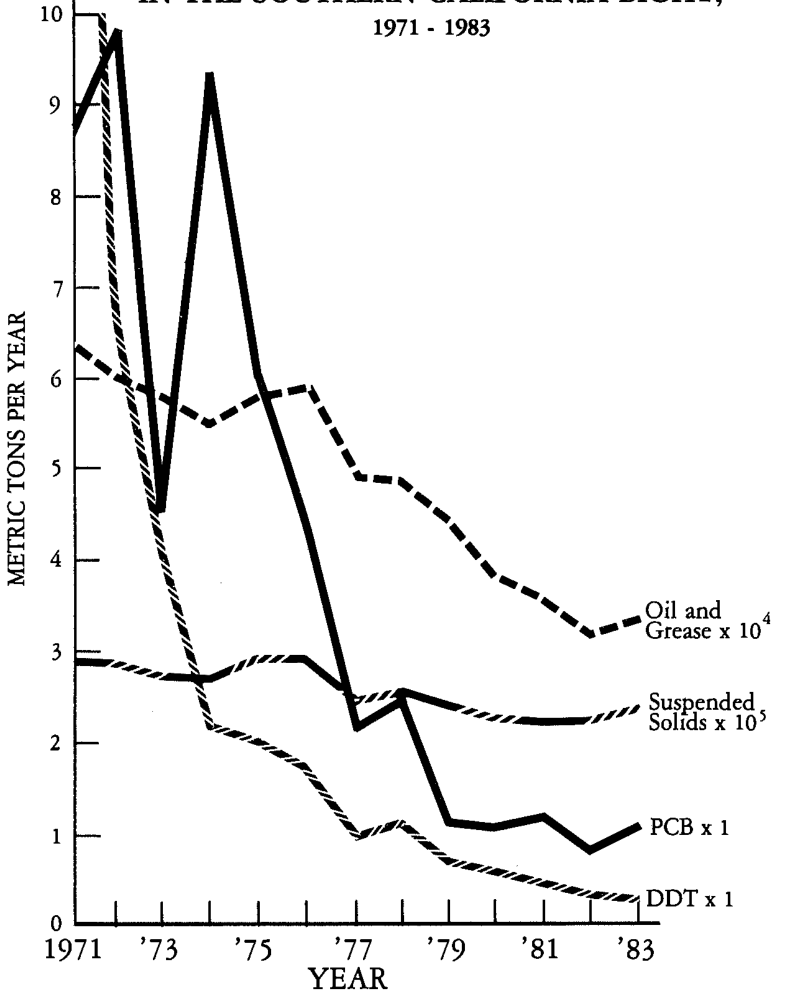
Significant attention has been given to the sources, distributions, and effects of synthetic organic chemicals, especially chlorinated hydrocarbons at selected locations around the coastal United States; in a few cases, it is possible to compare the magnitudes of direct deliberate disposal into the marine environment with inputs from nonpoint sources and river runoff.

The mass emission rates for PCBs and DDT in municipal waste waters discharged into the Southern California Bight near Los Angeles have steadily declined in recent years (Figure 2–4), mainly as a result of source control.[36] The total quantity of DDT discharged into the Southern California Bight in 1983 was about 200 kilograms, only about 1 percent of the amount released in 1971. Municipal waste water discharges are a major contributor of most contaminants to the Southern California Bight (Table 2–16), but the flow of municipal waste water into this system far exceeds the combined flows of industrial discharges and surface runoffs.[37] However, the substantial inputs of DDT and PCBs from the waste water discharge are probably exceeded by atmospheric inputs of these materials, at least since 1976 (Table 2–17).

The Hudson-Raritan Estuary, a highly industrialized coastal embayment near New York City, has also received considerable attention relative to contaminant loadings. In contrast to the Southern California Bight, about 85 percent of the water flow through the estuary (exclusive of tidal flushing) arises from riverine and land runoff. Waste water discharges account for about 13 percent of the total flow.[38] Although relative suspended solids input corresponds closely to the total flows from riverine, waste water, and urban runoff sources, almost one-half of the total oil and grease input to the estuary originates from waste water. Urban runoff contributes 34 percent, while river runoff accounts for only about 12 percent of the total oil and grease. Spills were estimated to contribute about 6 percent of the total.[39] For most synthetic organic materials, data are unavailable either for the atmospheric inputs or dissolved materials in the Hudson River. Figure 2–5 illustrates the ranges of estimates, however, for PCB loading of the Hudson-Raritan Estuary from all sources. Together, waste water discharges and riverine sources account for about 80 percent of the total PCB input to the estuary.[40] The data in Table 2–17 and Figure 2–5 serve to illustrate the magnitudes of contaminant inputs and the relative importance of different contaminant sources for two U.S. coastal water bodies that are among the most heavily used in terms of waste disposal.

FIGURE 2-4

MASS LOADINGS OF SELECTED CONTAMINANTS IN THE SOUTHERN CALIFORNIA BIGHT, 1971 - 1983



SOURCE: Schafer, H. A., "Characteristics of Municipal Wastewater, 1982-1983," *Southern California Water Research Project, Biennial Report 1983-1984* (Long Beach, CA.: 1984).

Ocean dumping of sewage sludge from the New York-New Jersey Metropolitan area continued through 1984 at the 12-mile site in the New York Bight. This site shows extensive signs of environmental degradation, including high levels of bacteria that caused the site to be closed for shellfishing, decreased diversity of benthic marine life over a broad area, and high levels of potentially toxic metals and organic compounds, including PCBs, in the sediments.[41;42] The sewage sludge and dredge materials barged directly to New York Bight

Table 2-16. Comparison of Waste Water Discharges and Riverine Inputs (metric tons per year) of Selected Constituents to the Southern California Bight, 1971-1972

General Constituent	Municipal Wastewater	Industrial Discharge	Surface Runoff
Flow (10^{10} liters/yr)	138	25	24
Total Susp. Solids	278,000	16,000	274,000
Volatile Susp. Solids	179,000	---	---
BOD (5-day)	291,000	6,000	---
COD	675,000	78,000	29,000
Oil and Grease	65,000	2,200	4,400
Dissolved Silica (Si02Y)	33,000	---	2,800
Nitrate Nitrogen	530	---	980
Ammonia Nitrogen	59,400	9,500	440
Organic Nitrogen	24,800	---	1,090
Total Nitrogen	84,500	10,000	2,510
Phosphate Phosphorus	13,300	---	410
Detergent (MBAS)	7,600	---	66
Cyanide	210	---	11
Phenols	1,730	43	269

Source: Mearns, A. J. and D. R. Young, "Characteristics and Effects of Municipal Wastewater Discharges to the Southern California Bight, a case study. Appendix A," *Ocean Disposal of Municipal Wastewater: Impacts on the Coastal Environment, Vol. 2.,* edited by E. P. Meyers and E. T. Harding (Cambridge, MA.: Massachusetts Institute of Technology Sea Grant College Program, MITSG 83-33, 1983), pp. 761-819.

Table 2-17. Estimated Annual Inputs (kg/yr) of Selected Chlorinated Hydrocarbons to the Southern California Bight From Different Sources

Route	Year	Total DDT	Dieldrin	1242 PCB	1254 PCB
Muni. waste water	1972	6,490	100	19,200	260
Muni. waste water	1973	3,920	280	1,900	1,510
Muni. waste water	1974	1,580	95	4,270	1,020
Muni. waste water	1975	1,270	---	2,400	680
Muni. waste water	1976	940	---	2,200	590
Muni. waste water	1977	770	---	1,260	300
Harbor indust	1973-74	40	10	70	30
Antifoul. paint	1973	1	---	1	1
Surface runoff	1971-72	100	20	100-170	90-110
Surface runoff	1972-73	320	65	0-550	250-280
Aerial fallout[1]	1973-74	1,400	---	---	1,100
Ocean currents	1973	7,000	---	---	4,000

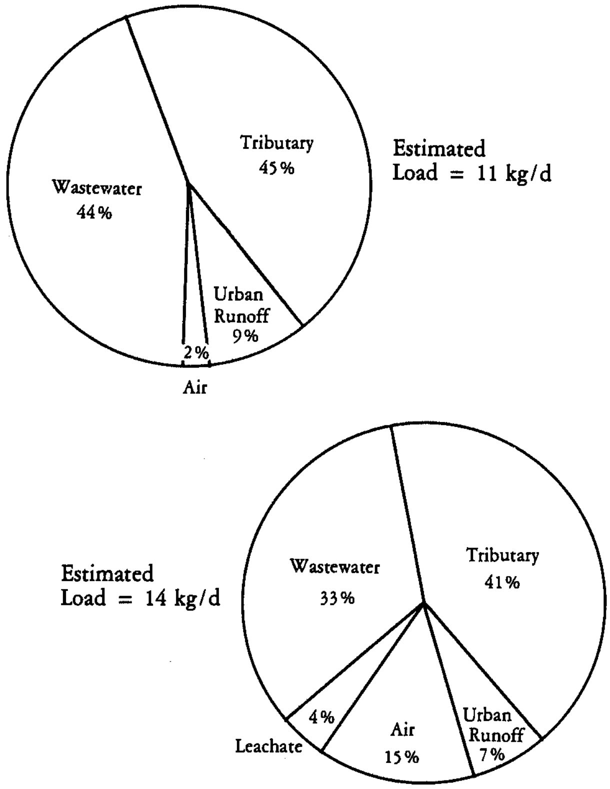
[1]Inner coastal zone: 400 x 50 km.

Source: Mearns, A. J. and D. R. Young, "Characteristics and Effects of Municipal Wastewater Discharges to the Southern California Bight, a case study. Appendix A," *Ocean Disposal of Municipal Wastewater: Impacts on the Coastal Environment, Vol. 2.,* edited by E. P. Meyers and E. T. Harding (Cambridge, MA.: Massachusetts Institute of Technology Sea Grant College Program, MITSG 83-33, 1983), pp. 761-819.

FIGURE 2-5

SOURCES AND LOADINGS OF PCBs INTO THE HUDSON-RARITAN ESTUARY

(Range of Estimates)



SOURCE: Mueller, J. A., T. A. Gerrish, and M. C. Casey, *Contaminant Inputs to the Hudson-Raritan Estuary,* (Boulder, Colorado: NOAA technical memorandum OPA-21, Office of Marine Pollution Assessments, 1982).

dumpsites have been estimated to contribute 63 percent of the total suspended solids input to the New York Bight, with the balance derived primarily from river and urban runoff.[43] Most of the suspended solids and more than half of the inputs of cadmium, copper, urban runoff, and substantial fractions of the total inputs of PCBs are also derived from waste water, riverine, and runoff sources, atmospheric inputs and dredged materials.[44] After several years of litigation and numerous hearings, the EPA ruled, on April 1, 1985, that dumping of sewage sludge should cease at the 12-mile site and should be moved

to a deepwater dumpsite 106 miles from New York Harbor. The overall stress to marine ecosystems will be reduced by this action (the 106-mile site is over 2,000 meters deep and is a highly dispersive current regime so that no benthic effects are predicted), especially to the local ecosystems of the New York Bight where the greatest numbers of fish and shellfish species occur. The substantial inputs of contaminants to the New York Bight from other sources, however, including coastal waste water discharges, urban runoff, atmospheric inputs, and dredged material disposal make it uncertain how rapidly marine environmental quality will improve in the Bight as a result of relocation of the sludge dumpsite.

Petroleum Inputs to World Oceans

While the amounts of crude oil produced offshore and the volume of petroleum and petroleum products transported at sea have increased over the last decade, estimates of total petroleum input to the oceans have decreased since 1975.[45;46]

Petroleum inputs to the oceans are approximately evenly divided between production and distribution activities, on the one hand, and use and disposal processes on the other (Table 2–18). Approximately two-thirds of the production/distribution inputs result from various operational phases of marine transportation. Since accidental spillage is also derived almost entirely from tanker accidents, a very substantial portion of the total input is related to transportation activities. Municipal wastes are probably the most significant pathway for return of petroleum to the oceans after its initial distribution. Municipal waste waters are discharged either directly into coastal waters or into rivers that carry the materials to the ocean. The estimated inputs from specified human-related activities in Table 2–18 generally have the smallest uncertainties associated with them (e.g., offshore production, marine terminals, tanker operations), because of surveillance and regulation of losses. The greatest uncertainties (broadest range of estimates) are associated with the estimates for inputs from natural sources, atmospheric inputs, and urban and river runoff.

Coastal and Estuarine Habitat Modification

Coastal and estuarine wetland habitats (marshes) represent one of this country's most valuable natural and renewable resources. Because of their relatively high primary productivity, marshes are a valuable source of food and also serve as spawning and nursery grounds for many commercially or recreationally important species of finfish and shellfish. Marshes are also credited with other valuable attributes, including flood and erosion protection. The productivity of wetlands and their proximity to shore make them especially important for commercial and recreational fishing. Research has shown that more than two-thirds of this country's commercially important fish species on the Atlantic and Gulf coasts are wetland-dependent at some stage of their life cycle. In addition, in the Pacific Northwest, coastal wetlands along spawning streams are vital to many salmon species. Important wetland habitats are being lost persistently, however, to urban developments and other coastal activities. Almost one-half of the coastal wetlands in the conterminous United States have been

Table 2-18. Comparison of Estimates of Global Inputs of Petroleum to Ocean Waters, 1974–1984 in Millions of Metric Tons Per Year

Source	1975 Estimates[1]	1984 Estimates[2]
Natural sources	0.6	0.25 (0.025–2.5)
Production and Distribution	2.413	1.62 (1.05–3.28)
Offshore production and coastal refining	0.28	0.15
Transportation-related operations[3]	1.833	1.05
Accidental spills[4]	0.3	0.42
Use and Disposal	2.5	1.08 (0.525–2.52)
Municipal wastes	0.3	0.7
Industrial wastes	0.3	0.2
Urban and river runoff	1.9	0.16
Ocean dumping	NA[5]	0.02
Atmospheric Inputs[6]	0.6	0.3 (0.05–0.5)
Total	6.1	3.3 (1.7–8.8)

[1]NAS, 1975.
[2]NAS, 1985. Ranges are shown in parentheses for some of the best estimates.
[3]Includes tanker operations, drydocking, marine terminals, bilge, and fuel oil bunkering.
[4]Includes transportation and non-transportation accidents.
[5]NA = not available (not estimated).
[6]Atmospheric sources are derived in part from natural and production-related processes, but probably mostly from fuel consumption (combustion).

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Ocean Assessments Division (Rockville, MD: 1985).

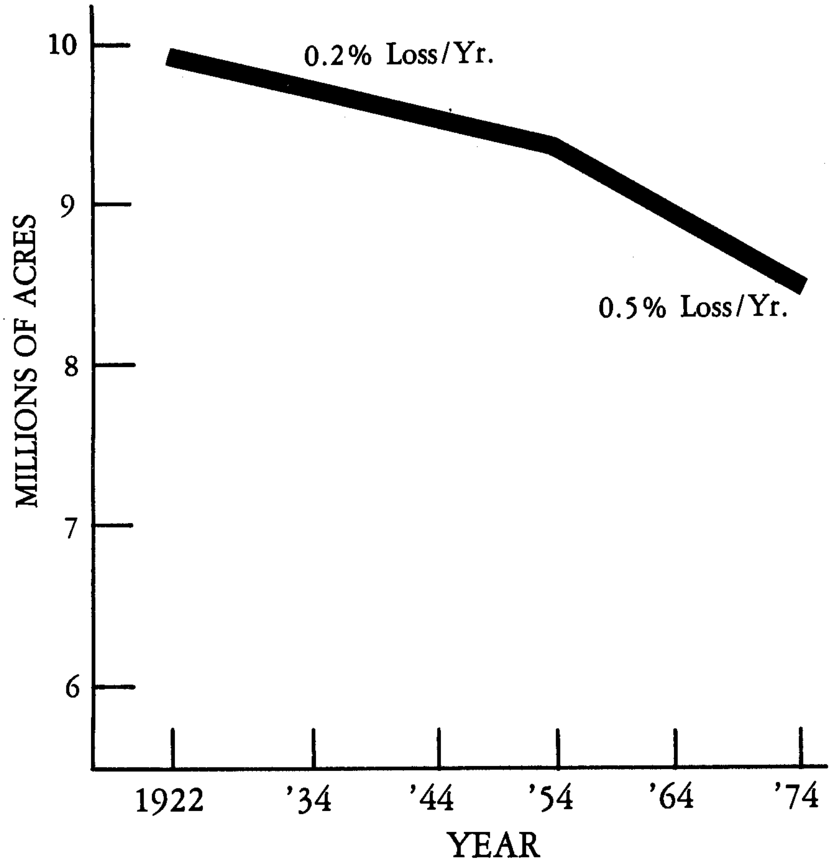
destroyed since the 1700s. The rate of loss has been greatest during the last three decades (Figure 2–6). Estuarine wetlands are still eagerly sought by developers for residential and resort housing, marinas, and other uses.

Estuarine wetland losses have been greatest in five states: California, Florida, Louisiana, New Jersey, and Texas. Louisiana is losing wetlands at a rate of 25,000 acres per year due mainly to coastal subsidence and other causes.[47] Outside of Louisiana, coastal wetland losses are directly related to population density. Urbanization (i.e., residential home construction) has been responsible for over 90 percent of the losses directly attributed to human activities.[48]

San Francisco Bay provides an interesting example of tidal wetland alteration. San Francisco Bay is an important wintering area for waterfowl: about 25 percent of the continent's population of whistling swans winter there, as do about 40 percent of North America's ruddy ducks. Of the more than 200,000 acres of coastal marshes that existed originally in the Bay region, less than 20 percent remain today.[49] Most of the original wetlands were filled for urban and industrial development, while many remaining tidal marshlands were diked to create salt-evaporating ponds.

FIGURE 2-6

COASTAL WETLAND LOSS IN THE CONTERMINOUS UNITED STATES



Estimates include both estuarine and tidal freshwater losses.

SOURCE: Tiner, R. W. Jr., *Wetlands of the United States: Current Status and Recent Trends* (Washington, D.C.: U. S. Department of the Interior, U. S. Fish and Wildlife Service, 1984).

Reproductive and Pathological Effects of Pollutants

There is growing evidence that the reproductive success of some marine organisms may be affected in some areas by chemical contamination. In San Francisco Bay, researchers found that the success of fertilization of eggs spawned by flounder was inversely related to the enzymatic activity of mixed function oxidase (MFO) in the livers of the parent fish. In turn, the MFO activity increased with exposure to high-molecular-weight organic compounds. While the causal mechanisms and relationships are not understood for these observations, they suggest that the present level of contaminant exposure may be sufficient to affect reproduction in this species.[50]

Related studies carried out near the waste water outfalls in the Southern California Bight have demonstrated high levels of atresia (resorption of more than 10 percent of the developing oocytes) in the ovaries of longspine combfish and yellowfin sculpins.[51] These latter results are still somewhat equivocal, however, because fish from a presumed reference site exhibited similar concentrations of PCBs and DDT in their tissues and showed similar rates of atresia. Delayed follicular development was also observed in ovaries of flatfish exposed to oil after the grounding of the *Amoco Cadiz* off the coast of Brittany, France, in 1978,[52] and the percent viable hatch of Baltic flounder eggs also decreased with increasing concentration of PCBs in the ovary of the parent female.[53]

Together these studies emphasize the continuing need for surveillance and research on the distribution, movements, and effects of persistent toxicants in the marine environment. The routes and rates of impact of these materials to coastal waters are diverse and are not all readily regulated or controlled, making their accumulation and effects in marine ecosystems and organisms very difficult to assess or predict. Of particular concern are the halogenated hydrocarbon compounds, commonly used as bacteriocides, herbicides, and pesticides, or (as in the case of PCBs) in electrical components such as capacitors and transformers.

Scientists from NOAA's Northwest and Alaska Fisheries Center in Seattle have documented high prevalences of liver and kidney lesions in Puget Sound bottomfish from certain urban embayments and waterways with high sediment concentrations of chemical contaminants.[54] A variety of liver diseases have persisted for a five-year period in populations of English sole and rock sole from these areas, and significant temporal trends have been observed in the incidence of neoplasias and specific necroses in these fish. A large number of factors (including age, fish movement, and seasonal variation) could influence these trends in lesion prevalence, however, and the specific causes of these changes are not clear.

To test the effects of contaminated sediments on fish health, English sole from Puget Sound were exposed under controlled laboratory experimental conditions to contaminated sediments from the Duwamish Waterway in Seattle. After four months of exposure, significant differences were observed between test and control fish in the incidences of lesions in gill, spleen, kidney, and liver. The specific lesions observed in the experiment, however, are rarely observed in English sole taken from contaminated waterways in Puget Sound. Sole exposed to contaminated sediments also demonstrated impairments of liver function similar to those observed in fish sampled from contaminated areas

and in fish exposed to known hepatotoxins in the laboratory. The results suggest, therefore, that exposure to sediments from Duwamish Waterway may cause chronic toxicity in certain fish. Either the duration of exposure or the levels of chemical contamination in the sediment were too low, however, to cause definitive chronic effects in these relatively short-term laboratory studies. After four months of exposure in the laboratory, tissue concentrations of contaminants were still considerably less than those reported for English sole taken from the Duwamish Waterway.

Increased incidence of histopathological abnormalities, tumors, and other lesions have also been noted in other U.S. coastal areas. Scorpion fish from the southern California Bight exhibit extensive hypertrophy and vacuolation of liver cells. These conditions appear to correlate more closely with the concentrations of oxygenated metabolites of DDT and PCBs in the liver tissue than with the parent chlorinated hydrocarbons.[55] The occurrence of abnormalities in finfish in Chesapeake Bay appear to be associated with high concentrations of polynuclear aromatic hydrocarbons, especially in parts of Baltimore Harbor and the Elizabeth River estuary near Norfolk.[56] Abnormalities observed in fish from these areas include cataracts, fin erosion, and other lesions of the skin, gill, and liver. The specific causes for these pathologies remain unclear, and their incidence is no doubt influenced by numerous factors. Nonetheless, the presence of liver lesions, and especially hepatic neoplasms, in bottomfish is considered to be a valuable indicator of pollution-related effects in marine environments. The observations and conclusions from the studies in Puget Sound and other locations have been instrumental in NOAA's design of a National Program on the Status and Trends of Environmental Quality in the nation's coastal marine waters.

Trends in Shellfish Closures

Since 1966, periodic data have been compiled nationally on the state-by-state classification of coastal and estuarine waters with regard to suitability for shellfishing activities. The individual state shellfish control agencies designate areas as suitable or unsuitable for harvesting of shellfish based on surveys of pathogenic microorganisms, industrial wastes, and marine biotoxins.[57] Table 2–19 summarizes these classifications for the northeastern states from Maine to Virginia for the period 1966–1985.[58;59] Analysis of long-term trends in these data is hampered because different states use different classifications and criteria, and because of shifts of acreage between classification categories. For example, between 1974 and 1980, acreage previously classified (by New York and New Hampshire, principally) as nonproductive was reclassified either as approved or prohibited. This reclassification did not necessarily result from changes in water quality. Between 1971 and 1985, however, the total shellfishing area designated as unsuitable for harvest (prohibited) was essentially unchanged for this region. Data for 1985 are not available for other regions as of this writing, precluding comparable analysis on a nationwide basis. These data are being compiled currently by NOAA's Ocean Assessments Division.[60]

THE GREAT LAKES

The Midwest has been graced with many resources, but none more dominant

Table 2-19. **Changes in Classification of Estuarine Shellfish Acreage in the Northeastern U.S., 1966-1985**[1]

	1966	1971	1974	1980	1985
	----- Thousands of acres -----				
Total acreage classified	4742	7105	7108	7107	7119
Classification	——— Percent of total ———				
Approved for shellfishing	90	72	71	78	78
Shellfishing prohibited	10	10	10	11	11
Conditional/Restricted Shellfishing	1	2	1	2	2
Non-Productive	0	16	18	9	9

[1]All coastal states from Maine to Virginia, inclusive.

Sources: Verber, J. L. *1980 National Shellfish Register of Classified Estuarine Waters* (Davisville, RI: U.S. Food and Drug Administration, 1981), and NOAA Ocean Assessments Division, Strategic Assessment Branch (1985).

or life-sustaining than the Great Lakes. From the deep and turbulent Superior to the heavily traveled Ontario, the five lakes are an important conduit for the nation's commerce. Freighters carry iron ore from the mines of Duluth across Lakes Superior and Michigan to the steel mills of Gary, while grain from the nation's "breadbasket" is shipped to the Mississippi and St. Lawrence Rivers for export. In addition to steel mills and ports, the lakes support recreational and fishing industries with combined total revenues of more than $1.1 billion a year.

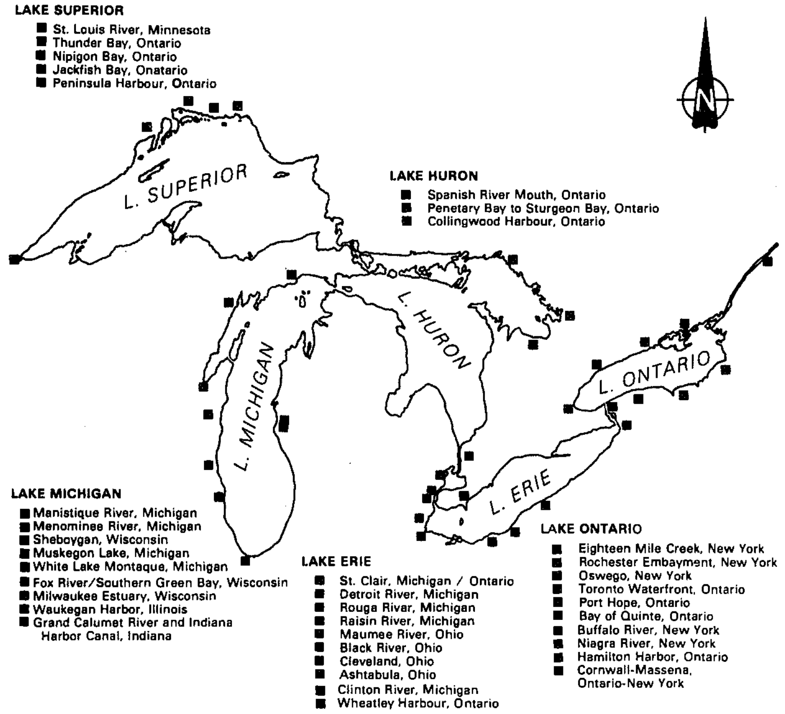
Despite their awe-inspiring size, the lakes are especially sensitive to environmental insult. Only one percent of the water entering the Great Lakes system flows out the St. Lawrence River in any single year, leaving toxic pollutants to accumulate in bottom sediments or fish. EPA has helped identify 37 "areas of concern" in the U.S. and Canada where the use of Great Lakes water is limited.[61] These areas include those where environmental degradation and impairment of beneficial uses is severe, and those where some environmental degradation is obvious and where uses may be impaired. These sites are illustrated in Figure 2-7.

Lake Superior

Lake Superior, the largest, deepest, and cleanest of the Great Lakes, has not entirely escaped pollution. Taconite mining residues, similar to asbestos particles, have been found in the drinking water of communities on the western shores of the lake, forcing them to install filtration plants for the first time. PCB levels in lake trout still exceed the standards, although levels of toxicants in herring gull eggs appear to be falling. Eutrophication is not considered to be a serious environmental problem in Lake Superior.

FIGURE 2-7

AREAS OF POLLUTION CONCERN AROUND THE GREAT LAKES



SOURCE: Environmental Protection Agency, Region V, *Report on the Environment - Region V, 1983* (Chicago, Illinois: USGPO, 1984).

Lake Michigan

Lake Michigan, the only one of the Great Lakes entirely within the U.S., has serious contamination problems. One of the major problems is the large amounts of PCBs discharged into Waukegan Harbor at Waukegan, Illinois, over a period of many years. Because it is a long, narrow cul-de-sac, Lake Michigan requires a longer period to flush itself of contaminants than do most of the other lakes.

Lake Michigan trout still contain the highest levels of PCBs and DDT in the Great Lakes system, except for Lake Ontario, and exceed U.S. Food and Drug Administration limits for commercial sale. Consumption advisories for sports fishermen are in effect in many parts of the lake.

Serious water pollution problems persist near the major urban or industrial

areas, most notably in the vicinity of the Calumet River-Indiana Harbor, Indiana. Other major areas of concern are: Southern Green Bay, the Milwaukee Estuary, Wisconsin; and Waukegan Harbor, Illinois.

Lake Huron

Following Lake Superior, Lake Huron is the least polluted of the lakes. However, discharges into the Saginaw River have made the Saginaw Bay area an area of concern.

Fish consumption bans are in effect for portions of the Saginaw River because of PCBs, PBBs, and dioxin, and a fish consumption advisory is in effect for southern Lake Huron and Saginaw Bay. The bay has recently shown substantial improvement, mainly because of effective municipal waste water treatment. But existing pollutants and a lack of controls on agricultural runoff complicate water quality problems there.

Lake Erie

With an average depth of only 58 feet, Lake Erie is the most shallow of the Great Lakes and has the smallest volume of water. Since its drainage basin contains the largest population of any of the lakes and is also heavily industrialized, it is not surprising that Lake Erie has faced the most severe and widely publicized pollution problems.

At one time in the mid-1960s, massive algae blooms choked off oxygen to 65 percent of the lake's bottom water. Pollution, overfishing, and other conditions devastated the lake's most desirable species of fish. Many lakeshore beaches were closed because of pollution caused by untreated sewage and masses of algae.

Considerable progress has been made since then, especially in reducing municipal and industrial discharges. Almost all municipal dischargers are now complying with international phosphorus limits, and many area counties are encouraging farmers to use no-till methods that will reduce soil losses, thereby improving water quality and reducing farming costs.

Seven areas of concern affect Lake Erie. These are located on the Rouge, Detroit, Raisin, Maumee, Black, Ashtabula and Cuyahoga rivers.

Lake Ontario

Although its water quality is better than Lake Erie's, Lake Ontario suffers from accelerated eutrophication due to excess phosphorus loading and also from toxic contamination. Mirex and other toxic substances of industrial origin have reached the Niagara River and Lake Ontario, resulting in a fish consumption advisory for fish caught in both U.S. and Canadian waters of the lake.

As in Lake Erie, some improvement has been made, but continued efforts are necessary. To a considerable extent, improvement in Lake Ontario depends on improvement in Lake Erie.

In the U.S., the major area of concern affecting Lake Ontario is the Niagara River, where much improvement is expected when existing pollution control programs are fully implemented. Since the Niagara-area problems are great, substantial abatement efforts are well underway.

IJC Report on Great Lakes Water Quality

The 1983 Report of the Great Lakes Water Quality Board of the International Joint Commission[62] focused on eutrophication and toxic chemicals as the two major system-wide environmental quality problems of the lakes, and reported as follows:

Eutrophication

Man-induced acceleration of eutrophication due to the discharge of untreated and partially treated sewage, industrial discharges, and land runoff (primarily from agricultural land use), was identified as the major water quality problem for the Great Lakes in the late 1960s. The Commission documented this phenomenon in its 1970 Report on Pollution of Lake Erie, Lake Ontario, and the International Section of the St. Lawrence River.

Under the 1972 Canada-United States Great Lakes Water Quality Agreement, the Parties, in cooperation with state and provincial governments, directed a two-pronged attack on eutrophication by encouraging the limiting of phosphorus content in household laundry detergents throughout the Great Lakes Basin and by requiring in the Lower Lakes Basin the reduction of phosphorus in municipal effluent to a concentration of 1.0 milligram per litre (mg/L) from sewage treatment plants with flows greater than one million gallons per day.

The Board reported that in 1982 the municipal waste water treatment plants in the Lake Erie Basin achieved an overall average effluent phosphorus concentration of less than 1.0 mg/L and thereby are beginning to meet the phosphorus loading reductions required in the 1972 Agreement. The treatment plants in the Lake Ontario Basin discharged effluent, with an overall average phosphorus concentration of 1.2 mg/L, with the excess loadings resulting primarily from plants in upstate New York along the St. Lawrence River, which are not required to provide phosphorus removal.

In spite of this overall (average) achievement of phosphorus reduction by municipal sewage treatment plants, some large individual plants in the Lower Lakes Basin were meeting the 1.0 mg/L effluent concentration required under the Agreement in 1982. These were: Cleveland Southerly and Cleveland Westerly in Ohio; Wyandotte in Michigan; London Greenway, Toronto Humber, and Hamilton in Ontario; Niagara Falls, Buffalo, and Amherst in New York.

On a system-wide basis, phosphorus inputs from industrial sources constitute less than 10 percent of the total municipal load to the lakes. However, industrial dischargers are significant contributors of phosphorus in some areas of concern.

The Board concluded that while industrial phosphorus inputs do not constitute a major system-wide problem, their contribution to specific areas of concern demands greater jurisdictional attention.

The phosphorus content in household laundry detergents is limited to the 0.5 percent level in New York, Indiana, Michigan, Minnesota, and Wisconsin, which acted to reinstate the limitation effective January 1, 1984. In Ohio, while no state-wide limitation exists, municipalities such as Akron have imposed a similar limitation. In Canada, phosphorus in laundry detergents is limited to 2.2 percent through a nationwide regulation under the Federal Canada Water Act.

The Board urged the Commission to continue its support of the imposition of basin-wide limitations on the phosphorus content of laundry detergents.

The efficacy of these phosphorus control efforts is reflected in the improvement of lake water quality, especially in the Lower Great Lakes.

In Lake Ontario, the spring total phosphorus concentrations in the open waters of the lake continue to decline (see Figure 2–8). The median total phosphorus concentration of 13.5 micrograms per litre (μg/L) reported for 1982 was the lowest reported in the last 13 years. Improving conditions in the lake are also indicated by a shift in the composition of the open lake phytoplankton community from one containing mesotrophic forms to one with species more indicative of oligotrophic conditions.

In Lake Erie, total phosphorus concentrations measured in the spring for the period 1974 through 1980 in the west central basin reflect a decreasing trend (see Figure 2–9). Over the same period, analyses of chlorophyll *a* concentrations in the fall, a widely accepted measure of eutrophication, also indicate a retardation of the eutrophication process. It should be noted that the Board reports these findings cautiously because Lake Erie is the most shallow of the Great Lakes and therefore is particularly subject to meteorological conditions that cause short-term variations that can mask year-to-year changes in trophic conditions.

The mean total phosphorus concentrations measured in Lake Huron have not changed significantly since 1971. Given the oligotrophic condition of the lake at that time and confirmed in the report of the Upper Lakes Reference Study of 1977, the Board concludes that this condition meets the non-degradation requirement for the Upper Lakes as stipulated in the 1978 Canada-United States Agreement.

The 1980 intensive survey of Lake Huron indicated that a few areas in the nearshore zone suffer from eutrophic conditions. These include the mouth of Saginaw Bay and Thunder Bay in Michigan and the Ontario shoreline of southern Lake Huron.

With regard to Saginaw Bay, eutrophication was observed to be accelerating in the late sixties and early seventies. Over the period 1974 to 1980, algal species composition was observed to shift, however, from a predominance of blue-green species to diatoms and green algae. The Board concludes that this change is generally reflective of improved water quality and can be attributed to phosphorus controls implemented in local watersheds that drain into the Bay.

The Board report on Lake Superior, following intensive studies that were carried out in 1983–84, will not be available until 1986.

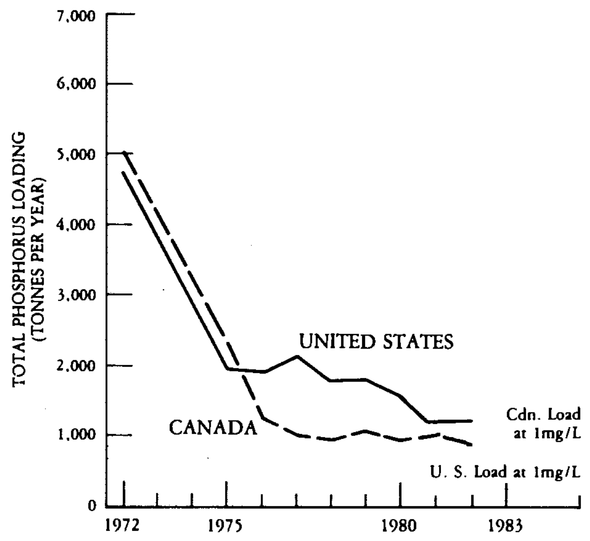
Toxic Chemicals

Largely through advances in analytical methodologies and improvements in detection instruments, the extent of Great Lakes contamination by complex organic chemicals has become apparent over the last decade. In each succeeding report the Board has reported the detection of more and more chemical compounds (from a dozen to over 800), which have been found in concentrations ranging from parts per million down to fractions of a part per trillion.

The presence of these chemicals in the Great Lakes has become a focus of public concern because many are labelled as carcinogens, mutagens, and teratogens based upon the results of test animals being exposed to relatively high concentrations of the contaminants under laboratory-controlled conditions. However, the long-term human health and environmental effects of most of the chemicals found in trace concentrations in Great Lakes waters are not

FIGURE 2-8

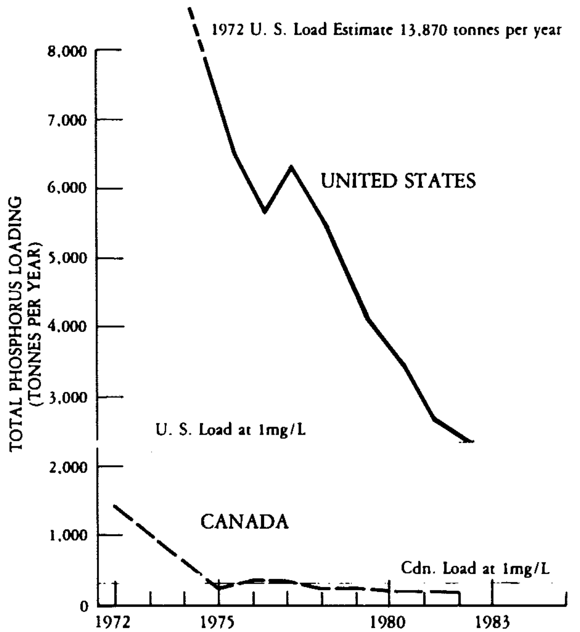
LAKE ONTARIO MUNICIPAL PHOSPHORUS LOADS



SOURCE: Great Lakes Water Quality Board, Report to the International Joint Commission, *1983 Report on Great Lakes Water Quality* (Windsor, Ontario: November 1983), p. 20.

FIGURE 2-9

LAKE ERIE MUNICIPAL PHOSPHORUS LOADS



SOURCE: Great Lakes Water Quality Board, Report to the International Joint Commission, *1983 Report on Great Lakes Water Quality* (Windsor, Ontario: November 1983), p. 20.

known. This basic lack of knowledge of chronic effects makes it extremely difficult for responsible agencies to establish control requirements.

Despite this lack of knowledge, the existence of these compounds, most of which are man-made, in the aquatic environment of the lakes is of primary concern. That concern stems from lack of basic knowledge of the long-term effects on human health and the natural environment from the substances at the minute concentrations at which they have been detected in the nation.

An even greater concern is that some of these compounds have been shown to bioaccumulate through the food chain to such an extent that the larger fish, such as trout, salmon, and walleye, have exceeded FDA standards for human consumption. Fish consumption warnings and advisories have been issued by state agencies to their sports fishermen and much of the commercial fishery has been banned by the FDA. Tumors and lesions are appearing with increasing frequency in Great Lakes fish, especially bottom-feeders such as carp and catfish. This was unheard of only a few short years ago.

A number of actions are being taken to deal with such toxic substances. For example, the Board is developing a priority list of chemicals for which further surveillance and/or characteristics and inventory information is required; establishing a clearinghouse of sources of information about characteristics of substances and their production and use in the Basin so that this information might be more readily available for use by the Great Lakes jurisdictions; and updating the 1976–78 compilations of chemicals that have been detected in the Great Lakes ecosystem.

Selected Issues in Water Quality

NONPOINT SOURCE POLLUTION

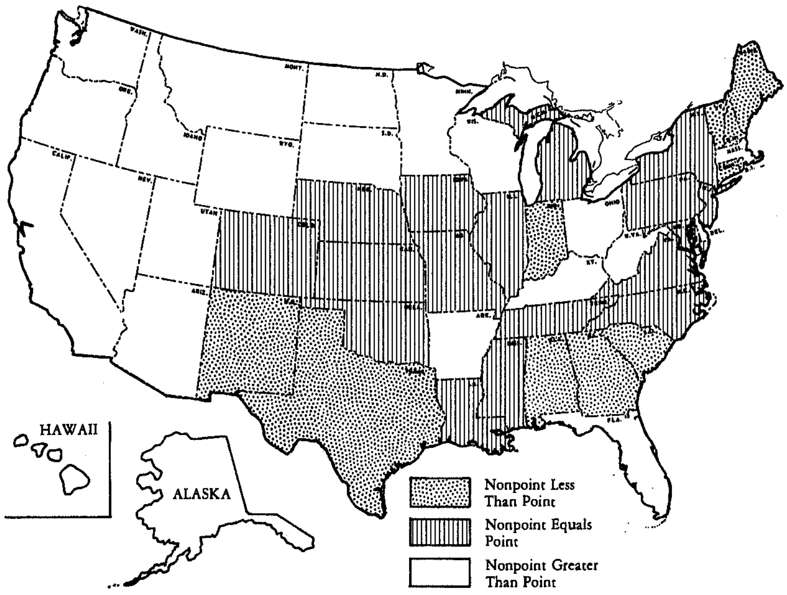
As point sources of water pollution have received greater control over the last decade, the remaining problem of nonpoint sources of water pollution has emerged more clearly. State and local water quality specialists cite nonpoint source (NPS) pollution as a leading cause of remaining surface water quality problems and also as a source of ground water contaminants. Further progress in achieving water quality goals will require accelerated implementation of NPS management programs, in addition to ongoing point source control efforts (see Figure 2–10).

There is a consensus that state and local management of NPS programs is the key to achieving water quality objectives. Only at this level is there enough flexibility to make site-specific and source-specific decisions needed to meet highly variable management needs. EPA and other federal agencies, of course, have an important policy role to play as well.

NPS programs often require cooperation between a large number of agencies and the private sector—the individual landowners and land users. For example, in the case of agriculture, the most widespread cause of NPS pollution, many agencies need to work together on solutions. State and local water resource agencies need to evaluate the water quality problems caused by agricultural practices. Also, the support of agricultural and land management agencies is needed to assist farmers and ranchers in changing the way they manage

FIGURE 2-10

STATE VIEWS ON THE MAGNITUDE OF NONPOINT SOURCE POLLUTION IN COMPARISON TO POINT SOURCE POLLUTION



SOURCE: Association of State and Interstate Water Pollution Control Administrators, Nonpoint Source Committee, Water Quality Management Task Force, *Analysis of the States' Response to ASIWPCA Nonpoint Source Pollution Survey* (February 1984).

their land to reduce NPS pollutants. Close cooperation between these agencies and carefully targeted programs are essential for achieving water quality goals. And, finally, the private sector plays the key role in implementing needed management practices.

Nature of the Nonpoint Source Problem

Nonpoint sources are commonly defined as diffuse sources of water pollution that do not discharge through a pipe. Examples include but are not limited to runoff and seepage from agricultural, silvicultural, mining, urban, and construction areas. NPS pollutants can come from a wide variety of land management practices, and most nonpoint sources do not discharge at a specific single location. In general, NPS pollutants are carried above, over, and through the ground by rainfall, runoff, infiltration, and snowmelt.

The definition of nonpoint sources is sometimes further complicated by legal distinctions. For example, when runoff is collected and discharged through a pipe—as is the case with combined storm and sanitary sewers, or runoff from active mines—it is usually considered to be a point source. There are exceptions, however, such as the Clean Water Act's definition of irrigation return

flows as a nonpoint source, despite the fact that the water is collected and returned to the stream through a discrete channel or pipe.

Nonpoint sources may generate both conventional and toxic pollutants, just as point sources do. Although nonpoint and point sources may contribute many of the same kinds of pollutants, these pollutants are generated and discharged in different volumes, combinations, and concentrations. For example, rain or snowmelt events that carry NPS pollutants to surface waters are generally less frequent and shorter in duration than continuous point source discharges. Conversely, infiltration of NPS pollutants into ground water aquifers may be a relatively continuous phenomenon.

Many recent studies demonstrate the pervasive nature of the NPS problem and its impact on surface and ground water and are discussed in the status and trends section of this chapter.

Other general assessments of NPS problems are ongoing. For example, ASIWPCA, under a second Cooperative Agreement with EPA, surveyed all states in 1985 to obtain a detailed, nationwide assessment of NPS problems and the status of state and interstate control programs. The assessment also included a survey of ground water problems. ASIWPCA will summarize the results of the surveys in a national report.

The Vulnerability of Estuaries, Lakes, and Impoundments to NPS Pollutants

Research suggests that lakes, impoundments, and estuaries are particularly vulnerable to NPS contaminants, as these water bodies serve as "sinks" for NPS pollutants.[63] While streams and rivers flush pollutants downstream—lakes, impoundments, and estuaries tend to trap pollutants and accumulate them in the water column, bottom sediments, and aquatic life. Although streams and rivers are damaged by NPS pollutants, more damage is caused in lakes and estuaries because of their pollutant-trapping efficiency. In essence, these water bodies serve as effective sediment traps.

In a recent paper Duda and Johnson conclude that because of the tendency for lakes to trap pollutants, lakes need more attention than rivers and can assimilate less pollution without damage.[64] The authors also conclude that the longer pollution abatement is delayed for a lake, the more expensive restoration is likely to be and the greater the risk of "irreversible damage." The paper reports that in a recent survey of states, NPS pollutants were identified as a major contributor to lake pollution.

Recently documented impacts on the Chesapeake Bay and other estuaries are also highlighting the vulnerability of coastal resources to NPS pollution.[65] As discussed in the case example on the Chesapeake Bay, increased loadings of phosphorus and nitrogen have depleted the Bay's oxygen supplies and caused algal blooms, and toxic metals are increasing in the bottom sediments. These problems clearly are aggravated by the Bay's hydrology; estuaries act as repositories for sediment and other pollutants that have entered upstream rivers. A recent commentary aptly described the Bay as "a sink, not a culvert to the Atlantic."[66]

The tendency for lakes, impoundments, and estuaries to serve as sinks for NPS pollutants points to a need for greater attention to these vulnerable resources. Currently, special efforts are being initiated for controlling NPS pollutants to these types of water bodies. The special vulnerability of these

resources should be considered as strategies are developed to address NPS pollution problems.

Nonpoint Source Control Efforts—A Brief History

Concerted efforts to understand the nature and solutions to NPS pollution were initiated in 1972 under Section 208 of P.L. 92–500, the Clean Water Act. Section 208 calls for states and area-wide agencies to develop and implement water quality management plans, with EPA plan approval and limited oversight. Through the 1970s, states developed initial water quality plans that addressed both point and NPS control needs. Funding under Section 208 provided an opportunity for states to assess their NPS problems and control needs and, to a much lesser extent, to implement control programs. After fiscal year 1981, states began using other sources, such as Sections 205(j) and 106, to fund NPS efforts. Also, some states and local governments have recently initiated their own NPS implementation programs.

The 1980s are seeing a renewed interest in NPS control as progress has been made to control many point sources, and pollution from nonpoint sources is recognized as a limiting factor preventing full attainment and maintenance of water quality goals. Prime examples are the NPS control efforts being initiated in the Chesapeake Bay and Great Lakes states. NPS control efforts will likely accelerate in these and other areas during this decade.

Many of the programs that are used for controlling NPS pollution did not receive their original impetus from a high priority concern for water quality; for example, many of them were designed primarily to control soil erosion and ensure continuing productivity, or to prevent floods. However, increasingly a number of management programs are being designed explicitly for controlling nonpoint sources of water pollution. For example, the states of Wisconsin, Idaho, Maryland, Pennsylvania, and Virginia have all developed state-funded NPS cost-sharing programs. In addition, there are several ongoing federally funded NPS demonstration projects. Also, a variety of federal programs provide important assistance for the management of NPS pollution, and federal agencies are responsible for the direct management of millions of acres of federally owned land.

Federal Programs

Although most federal programs are not explicitly designed only to control NPS pollution, a number do include NPS management activities. Federal NPS activities include: (1) direct management of federally owned land (Bureau of Land Management in the U.S. Department of the Interior, Forest Service in the U.S. Department of Agriculture (USDA), etc.); (2) a wide range of assistance programs for private landowners and land users; and (3) support for a variety of NPS demonstration and management programs. Following is a brief summary of these types of federal NPS activities.

First, huge landholdings are managed by the Bureau of Land Management, the Corps of Engineers, and the Forest Service for multiple-use purposes. Grazing, mining, forestry, and other activities take place on these publicly owned lands. Comprehensive planning processes are undertaken to ensure protection of the resource base and use of these lands for a variety of purposes.

Case Example:
Nonpoint Sources Contribute to Chesapeake Bay Pollution

The Chesapeake Bay has undergone degradation from both point and nonpoint sources of pollution. Nutrient levels have increased in many areas of the Bay, causing algal blooms in some parts. Low dissolved oxygen levels have been observed in large expanses of the Bay. Heavy metals and toxic organic compounds have been detected at elevated levels in both the water column and sediment, and evidence of the bio-accumulation of some of these toxic contaminants has been observed. Harvests of shellfish and freshwater spawning fish have declined. Submerged aquatic vegetation has decreased throughout the Bay, and the diversity and abundance of benthic organisms have declined as a result of the polluted waters.

A recent exhaustive study of the Chesapeake Bay has shown that both point and nonpoint sources contribute significantly to nutrient loadings: point sources (primarily sewage treatment plants) are the major contributors of phosphorus, while nonpoint sources are the main contributors of nitrogen. Specifically, Chesapeake Bay research studies show that 67 percent of the nitrogen and 39 percent of the phosphorus entering the Bay in a typical seven-month period come from nonpoint sources. Nonpoint sources of nitrogen include agricultural activities and urban runoff, the principal source being runoff from cropland.

Like nitrogen and phosphorus, toxic organic compounds and heavy metals are also contributed by both point and nonpoint sources. Point sources of toxic metals and organic compounds include industrial facilities and sewage treatment plants; nonpoint sources include urban runoff, dredged material disposal, atmospheric deposition, and acid mine drainage.

Many of these sources do not discharge directly into the Bay, but rather to tributaries that ultimately empty into the Bay. Large portions of the pollutants from the various sources are effectively trapped in the Bay and contribute to the water quality problems described above. In essence, the Bay becomes a "sink" or repository for sediment, nutrients, and other contaminants.

The documented water quality problems of the Chesapeake Bay have resulted in the Bay States initiating new NPS control programs and continuing their emphasis on point source controls. The new NPS initiatives being developed by the Chesapeake Bay States will likely serve as models for other areas of the nation.[67]

Second, agencies with programs that reach the land manager or that affect the relationship between the state and the land manager are key to the implementation of NPS controls for agriculture, silviculture, construction, and mining. Various USDA programs, for example, provide technical assistance and a range of incentives that affect the way a landowner chooses to manage his land. Although state and local governments increasingly are hiring more of their own staff (e.g., soil and water conservation district staff) to provide technical assistance and are developing state-funded incentive programs to address NPS pollution and other natural resource problems, they still rely heavily upon assistance from the USDA agencies, such as the Soil Conservation Service, Agricultural Stabilization and Conservation Service, and the Forest Service.

Relying on the established outreach capability of USDA and other agencies for implementation of NPS controls benefits from the record of mutual trust and effectiveness that these agencies have forged in the field. However, the statutory mission of these agencies may not always coincide with addressing NPS pollution problems.

Evidence for this is provided by recent research that indicates the costs of *erosion-induced off-farm damages* are much higher than the costs of *lost agricultural productivity*. This conclusion is based on a Conservation Foundation study that estimated the cost of off-farm erosion damage as ranging from $2 to $6 billion/year, with a point estimate of $3.1 billion/year. In contrast, erosion resulted in lost farm productivity of only about $40 million/year.[68]

These estimates suggest that more emphasis be placed on off-farm damages, such as NPS water pollution.

Another example of a federal agency that affects land managers is the Office of Surface Mining in the U.S. Department of the Interior. This Office implements the Surface Mining Control and Reclamation Act (SMCRA), which regulates the activities of operating and abandoned coal mines. Also, the Federal Highway Administration within the U.S. Department of Transportation grants billions of dollars in Federal Highway Trust Fund monies to construct interstate and federal highways and conditions such grants on the application of appropriate best management practices (BMPs). BMPs are methods, measures, or practices designed to prevent or reduce NPS pollution.

Third, a number of federal agencies support a variety of NPS demonstration and management programs. Notably, the experimental Rural Clean Water Program, conducted by USDA's Agricultural Stabilization and Conservation Service, with assistance from EPA and other agencies, is designed to provide incentives for the implementation of agricultural BMPs to solve NPS water quality problems. This program provides long-term technical and financial assistance to farmers in 21 experimental watersheds across the country.

In addition, EPA continues to support a variety of experimental, demonstration, and other NPS management programs, the results of which assist states and local governments in designing and implementing NPS programs. Specifically, Sections 106 and 205(j) of the Clean Water Act provide funds for water quality management that include support for state NPS activities. Also, EPA supports NPS implementation efforts for the Great Lakes and the Chesapeake Bay—both water bodies of national significance. EPA's Great Lakes Program provides funds for demonstration projects directed at controlling NPS pollution in several Great Lakes watersheds. EPA's Chesapeake Bay Program is providing

support to implement needed point and NPS controls in the watersheds of the Chesapeake Bay, based on the findings of research studies conducted under the Program. EPA's Clean Lakes Program also has provided cost-share funds for implementation of NPS controls to protect and restore lake water quality in selected lakes across the nation. These prototype efforts will hopefully provide insights and lessons for other future state and local NPS implementation activities in other parts of the U.S.

State and Local Programs

States and local governments have responded to their NPS problems in a number of ways. These responses vary according to the source of pollution and the technical, institutional, and political difficulties that arise in attempting to control it. The following brief discussion of state management of five specific types of nonpoint sources was drawn from EPA's "Report to Congress" on NPS pollution.[69]

Agriculture: Agricultural NPS pollution is addressed by a variety of state programs. Such programs typically contain educational, training, and cost-sharing components. Programs are generally voluntary but sometimes have some type of regulatory backup. These programs usually are implemented at the local level of soil and water conservation districts, with assistance from several branches of USDA. A number of state programs are successfully encouraging the adoption of conservation measures or BMPs that reduce erosion from farmland and pollution from other agricultural practices.

Silviculture: In states where the forest industry has significant landholdings and is very active, silvicultural programs tend to be regulatory or quasi-regulatory in nature. Regulatory programs manage silvicultural activities through state forest practices acts; quasi-regulatory programs rely on other laws, such as sediment and erosion control laws. In states where small-lot silviculture is more commonly practiced, voluntary, educational, and sometimes incentive-oriented programs are aimed at private landowners.

Mining: Control programs that address currently operating coal mines are regulatory in nature and derive their authority from the federal Surface Mining Control and Reclamation Act (SMCRA). Programs for abandoned mines usually involve the provision of financial assistance by state and federal governments through the abandoned mines programs of SMCRA, the Rural Abandoned Mines Program (RAMP), or individual state programs.

Urban Runoff: Programs have normally been conducted by municipalities and, to date, have been primarily directed at controlling the volume of urban runoff, although increasing attention is also being given to incorporating water quality considerations. Under EPA's current National Pollutant Discharge Elimination System (NPDES) permit program regulations, storm water discharges located in urbanized areas or at industrial facilities are considered point sources and are required to obtain a permit.[70]

Construction Erosion: Where they exist, programs for the control of construction erosion are regulatory in nature. About 16 states have effective regulatory programs. In states that do not have a statewide regulatory mandate, some individual local governments have passed local ordinances to control construction erosion.

Nonpoint Source Task Force Recommendations

Another recent activity related to controlling NPS pollution was the efforts of the federal/state/local Nonpoint Source Task Force. In March 1984, EPA convened a federal/state/local NPS Task Force, in recognition of the need for greater coordination among the numerous agencies involved in NPS management, the need for a clearcut definition of roles, and the need for accelerating the management of NPS pollution. The Task Force was charged with recommending to the EPA Administrator a national NPS policy for guiding agency implementation efforts and with developing agency strategies for implementing the national policy.[71]

A recommended National NPS Policy was adopted by the Task Force and presented to EPA's Administrator at the final meeting of the Task Force in December 1984. Also, during the nine-month period in which the Task Force met, individual federal agencies and some state agencies participating on the Task Force developed their own strategies to implement the recommended National NPS Policy.[72]

Key points in the recommended National NPS Policy include the following: (1) all levels of government and the private sector need to accelerate NPS implementation using existing resources; (2) NPS programs must be flexible to facilitate site-specific solutions, accommodate changes in technical knowledge, optimize on- and off-site benefits, and should focus on priority waters (both ground and surface); (3) states, in cooperation with local governments and the private sector, have the lead role in implementing NPS management programs; (4) EPA's role is to provide leadership and coordination; (5) the private sector has a key role to play—ultimate resolution of the NPS problems will depend heavily upon private sector cooperation, support, and commitment of manpower and resources; and (6) both voluntary and regulatory approaches should be utilized, as determined by state and local governments.

Issues in Future Management of Nonpoint Source Pollution

Development of the recommended National NPS Policy and agency strategies is an important first step in addressing some of the interagency problems inherent in NPS management and strengthening the commitment of individual agencies. However, a long-term commitment from agencies at all levels of government and the private sector will be necessary to ensure that progress toward meeting NPS objectives continues to be made.

In addition, a number of issues have been raised by the Task Force and ongoing NPS implementation efforts. Issues include the question of how one "targets" NPS implementation efforts, and the proper role of the federal government in managing NPS pollution. Although increasingly there is agreement that nonpoint sources contribute significantly to some remaining water quality problems and that implementation must take place at the state and local level, there is not always agreement on exactly *how* to implement effective NPS management programs. The state-of-the-art of managing NPS pollution is an evolving one. The question, "How does one target NPS management programs to make them effective?" would likely receive different answers depending upon whom is asked. However, we are beginning to build an experience base that should help to answer such questions.

For example, we know that for most water quality problems caused by

nonpoint sources, substantial water quality improvements can be—and have been —achieved cost-effectively through careful targeting of control activities. Effective approaches to targeting involve identifying both the priority waters (ground or surface) for which adoption of NPS control programs will have significant benefits and the location of source areas and appropriate management practices that will lead to the greatest improvements for the least cost.

As discussed above, the analysis and decision-making required for effective implementation of targeted controls must take place at the local level. Further, a key to careful targeting activities to maximize water quality benefits is a watershed-based analysis.

A number of states and local governments are beginning to design and implement watershed-based NPS implementation programs. The state of Wisconsin's Nonpoint Source Water Pollution Abatement Program, for example, has a highly developed approach to targeting NPS implementation efforts within specific watersheds. Other state and local governments (e.g., in the Chesapeake Bay region, other Great Lakes states, etc.) are experimenting with other approaches to targeting NPS implementation efforts. Some of these approaches undoubtedly will provide effective examples.

The above discussion highlights the key role of state and local governments in the implementation of NPS controls due to the need for site-specific and source-specific decision-making and the need for careful targeting of NPS implementation programs. But what is the proper role of the federal government in managing NPS pollution?

The federal government has three main areas in which it has an important role, including: (1) managing federal lands; (2) providing a network of outreach services; and (3) assisting NPS demonstration and management programs. The recommended National NPS Policy developed by the Task Force identified these roles as well. The recommended policy explicitly recognizes the important role of federal agencies in using available and future programs to provide state and local governments with technical assistance and support, and to conduct research and development.[73] The policy also recognizes federal agency responsibility for direct planning and management of NPS programs on public lands and for coordinating NPS management actions with all levels of government.

The policy also highlights EPA's role, as provided by the Clean Water Act, to serve as the lead agency in coordinating interagency and state actions for managing NPS programs. The policy calls for EPA to promote adoption of NPS management programs directed at achieving water quality goals; to assist with program development; to promote provision of incentives where needed; and to provide oversight of its water quality programs to ensure that they adequately address NPS problems. The policy also asserts EPA's role in coordinating with other agencies on NPS-related activities in research, education, demonstration projects, training, information transfer, technical assistance, and data collection and analysis.

The recommended National NPS Policy clearly recognizes the important role of the federal government in the management of NPS pollution. However, there is ongoing debate about how extensive federal involvement in NPS programs can and should be and what the exact nature of that involvement should be. For example, some argue that limited NPS technical assistance and program support from the federal government go a long way toward encouraging state

Case Example:
Wisconsin's Approach to Targeting NPS Controls

The Wisconsin Department of Natural Resources (DNR) is currently implementing a state-funded, watershed-based program. The program concentrates available funds in selected "priority watersheds" throughout the state. Watershed projects are selected to achieve specific water quality objectives. Once a particular priority watershed is chosen as an implementation project, the "priority management areas" contributing most significantly to the pollution problems are identified through a detailed planning process. All NPS categories (e.g., agriculture, silviculture, construction, urban, etc.) of concern in each watershed are addressed. All sources of concern in a watershed are addressed because water quality problems are seldom caused by a single type of nonpoint source.

Targeting of NPS implementation efforts occurs as a two-phase approach under the Wisconsin program. First, all 330 watersheds in the state are screened, and selected priority watersheds are chosen for implementation projects. Priority watershed projects are selected for concentrated attention based on six criteria:

1. The severity of the water quality problems;
2. The potential for pollutant load reduction;
3. The willingness of landowners to participate;
4. The willingness and capability of local agencies to carry out their role in the program;
5. The willingness and capability of local agencies and units of government to control other sources of pollution; and
6. The potential benefits to be achieved.

As indicated by the criteria, a mix of quantitative and less quantitative, more subjective information is used to select priority watersheds.

A second phase of targeting occurs during the development of individual "priority watershed plans," which include a detailed inventory and assessment of the critical source areas in the watershed and the project's water quality objectives. The priority watershed plan is a consolidation of water quality and land use information, so that the specific causes and critical areas ("priority management areas") contributing to the water quality problems can be identified and the most practical means for controlling the pollution can be developed.

It generally requires about one year to complete the watershed assessment and prepare the priority watershed plan. The watershed plan is prepared by staff from both the Wisconsin DNR and local governments. Barnyard, cropland, streambank, and urban area models are used by DNR technical staff to evaluate the significance of the sources.

Through this process, the critical land areas producing the majority of the pollutant load are identified and become the focus of project implementation. After the plan is approved, cost share agreements with landowners and municipalities are signed, requiring BMP installation within five years and binding cost-share recipients to operation and maintenance requirements for the life of each practice. Watershed project implementation generally takes about eight to nine years.

In summary, Wisconsin's approach to targeting is to focus implementation efforts in specific priority watersheds, which are carefully selected to maximize the potential for achieving identified water quality objectives. Wisconsin's approach also involves a second phase of targeting within selected priority watersheds, i.e., the identification of critical source areas. The program is based on the idea that it is essential to identify the critical land areas and operations producing the majority of the pollutant load. Detailed inventories and analysis conducted during the watershed planning phase allow these critical areas to be identified and ensure more efficient use of available time and money during implementation.[74]

and local governments to commit increased resources to address NPS pollution problems. Others argue that providing small amounts of seed money for implementation and demonstration is essential to achieving more activity at the state and local levels. Still others maintain that providing any federal financial assistance opens a "pandora's box" and in any case is unthinkable under current fiscal conditions.

Final resolution of these and related questions must await Congressional and Administration negotiation of reauthorization of the Clean Water Act, the Farm Bill, and other national natural resources legislation.

GROUND-WATER PROTECTION

Until recently, the nation's ground-water resource attracted very little attention from the general public and government. Residents of large cities gave little thought to the origin of their water supplies unless a major reservoir adjoined the city. In rural areas, long-term residents and vacationers usually were accustomed to drinking "clear, sweet well water." Even when water supplies were analyzed for various minerals, problems were rarely noted.

During the last decade, however, reports of ground-water contamination have grown. Newspapers and other media reported local stories about ground water, such as a well field closed due to industrial pollution, the discovery of an abandoned landfill, or the implications of municipal plans for sludge spreading. When more sophisticated laboratory techniques were used to test local water supplies, pollutants were often identified in supplies once thought free from contamination. While the total volume of contaminated ground water is believed to be extremely small, the public no longer takes for granted their "unseen" water resources.

Response to Ground-Water Contamination

At the national level, in response to the problem of ground-water contamination, EPA recently issued a Ground-Water Protection Strategy,[75] which provides a policy framework for greater coordination among the several statutes that form the basis of its ground-water programs. In addition, EPA took on major new authorities in the recent reauthorization of the Resource Recovery and Conservation Act (RCRA).

Other federal agencies have also placed greater emphasis on ground-water quality, principally through their research and data-gathering activities. The U.S. Geological Survey, in particular, is increasing its efforts to develop basic scientific information on the ground-water environment through research, investigations, and data collection. The survey's efforts focus on developing baseline information on the hydrologic, geochemical, and biologic process, distribution and composition of water-bearing materials, the potential for artificial recharge and its impacts; and the sources, quantities, qualities, distribution, and behavior of the ground-water resource.

In Congress, the Office of Technology Assessment's Report, "Protecting the Nation's Groundwater from Contamination" (October 1984)[76] was written in response to a request by the Senate Committee on Environment and Public

Works for an assessment of protection efforts. The report analyzes current ground-water programs, describes the ground-water resource, delineates the various impacts of ground-water contamination on the resource, and summarizes state-of-the-art technologies available for hydrological investigations and contamination abatement.

The private sector has also stepped up its ground-water activity. Many public interest, private, and scientific organizations have published reports relating to ground-water protection, including the Environmental Law Institute, the American Petroleum Institute, and the National Academy of Sciences. New groups have been formed to deal exclusively with the ground-water contamination problem. One example is the National Groundwater Policy Forum, created by the National Governor's Association and the Conservation Foundation. The reports and information being generated by these organizations are providing a resource base for ground-water program managers. These groups are also providing a knowledgeable forum for the debate of the very difficult public policy questions posed by ground-water contamination.

Accelerating activity is also apparent at the state and local levels, as it is here that the primary response to the effects of contaminated wells, leaking tanks, and pesticides and fertilizer contamination takes place. Their approaches to ground-water protection vary widely but evidence a clear commitment. Most states have formed task forces, ad hoc committees, and councils to develop statewide strategies for ground-water quality protection; some are in the implementation stage. Twelve states have passed new statutes to carry out their ground-water policies; many others rely on existing authorities. To date, 21 states (and territories) have developed policies for protecting ground-water quality and 31 states are formulating such policies.

States have undertaken a variety of actions to manage their ground-water resources. Those that have experienced major ground-water contamination problems and are quite dependent on ground water for drinking water are implementing extensive programs. Almost all states have begun collecting data related to ground water and have begun aquifer mapping programs. Some states have programs to protect specific aquifers within the state and others have formed interstate committees to protect interstate aquifers. Nearly all states have some ability to respond to contamination incidents, protect ground water from specific sources of contamination, and monitor certain areas for contaminants. A few have instituted land use policies and land acquisition to protect their underground supplies of drinking water. Most states have also assumed direct responsibility for managing one or several EPA programs that protect ground water, such as those for controlling underground injection of wastes and materials and hazardous waste management.

EPA's Ground-Water Strategy

An EPA Ground Water Task Force was established in the summer of 1983, and drafted a strategy which was distributed for public comment in January 1984. One purpose of the strategy was to rationalize and make better use of the many statutes EPA has at its command to protect ground water. These statutes provide EPA broad authority over certain contaminants and sources

of contamination. They did not change the states' principal responsibility for the overall protection of the resource.

EPA's Ground-Water Protection Strategy has four broad objectives: strengthen state programs; focus on currently unaddressed ground-water problems; create a policy framework for guiding EPA programs; and strengthen internal ground-water organization.

1. Strengthen State Programs

Program Grants: For FY 1985, Congress approved a $7 million supplement to the Clean Water Act Section 106 funds to be used in support of ground-water protection activities. Each state was eligible for a minimum grant of $100,000 and each territory for a minimum grant of $50,000. These grants were intended to support such activities as developing state strategies, initiating programs to improve their legal and institutional capability, developing state classification systems, conducting selected resource assessments, and compiling and managing ground-water data. These funds can also be used for program implementation. Most state grants have been awarded and range up to $350,000. Generally, the states are using these funds to support various combinations of the above activities. The President's budget for FY 1986 also includes $7 million for this purpose.

Ground Water Research Review: A major effort is underway to review and evaluate the scientific quality and direction of EPA's ground-water research program and to strengthen the technical basis of the Agency's regulatory activities. The EPA Science Advisory Board has assembled a group of nationally known scientific experts. A report from this committee will be released in 1985 and the results will be incorporated into EPA's research program. The group is particularly concerned with the research needs of states since they address a broader range of ground-water problems than are covered under federal statute.

Other Support to States: A variety of other activities are also underway to support state efforts. Regional Ground-Water Offices are working closely with states in developing their ground-water protection programs and are sponsoring state seminars on ground-water protection strategy development. A grant has been provided to the National Research Council to evaluate seven to 10 state and local ground-water protection programs to determine the most workable approaches. A series of symposia on state and local ground-water policy issues is being funded through a consortium of universities headed by the University of Oklahoma. A series of publications on state ground-water programs has been issued by the Office of Ground-Water Protection to help inform states of efforts underway in other jurisdictions.

2. Areas of Focus

EPA is concerned with several sources of ground-water contamination not fully regulated under federal environmental protection programs or that require a higher priority.

Leaking Underground Storage Tanks: Underground tanks are used to store a wide variety of liquids, including gasoline, domestic fuels, hazardous and toxic chemicals, and wastes. Leaking underground tanks can contaminate nearby soils, surface water, and ground waters and may result in fires and explosions

where the contents are flammable, or in the need to evacuate areas due to toxic fumes. The Strategy pointed out the growing evidence that leaking tanks are becoming a major cause of ground-water contamination.

In early 1984, EPA initiated a study to determine more precisely the nature and extent of the problem and then issued a chemical advisory to notify owners and operators of gasoline stations of the potential harm from leaks. Congress enacted amendments to RCRA in late 1984, which established an EPA program for the regulation of underground storage tanks.

Pesticides Contamination: Pesticide contamination of ground water is emerging as a significant environmental issue as more and more areas of the country are finding pesticides in private and public drinking water wells. Thus far, most of the reported contamination is at trace levels, which do not appear to present an immediate health risk, but there have been some cases where special treatment systems had to be installed or alternative water supplies found. To better characterize the extent of the problem, EPA is designing a national survey of pesticides in drinking water drawn from ground-water supplies. The results of this survey will be used to support pesticide registration decisions and will provide the occurrence data necessary for estimating human exposure for development of drinking water standards.

Using FIFRA authorities, EPA accelerated collection of environmental fate information on a class of pesticides suspected as likely leachers and is requiring some manufacturers to conduct extensive field-monitoring studies. Registrations of two pesticides—ethylene dibromide (EDB) and dibromo-chloropropane (DBCP)—have already been cancelled in part due to ground-water concerns. Advisory label statements and geographic restrictions on use have been required for several others. Many other pesticides are likely to be subject to such requirements as more data become available.

In addition to regulatory action under FIFRA, the Agency is exploring educational and technical assistance networks, such as those provided by the U.S. Department of Agriculture, to inform farmers about the problem and implement practical methods for reducing the risk of leaching.

Landfills and Surface Impoundments: Studies to determine the impact of nonhazardous waste landfills and surface impoundments on ground-water quality were initiated in late 1984. The studies will examine the extent to which these sources contribute to ground-water contamination as well as what type, if any, regulatory controls are needed. An assessment of state surface impoundment programs began in February and will continue into the spring of 1986. At that time work will begin on a regulatory option program.

3. A Policy Framework

One of the critical elements in achieving consistent protection across EPA programs is the implementation of a ground-water classification system. The purpose of the classification system is to assure that management decisions, such as permitting of facilities, degree of cleanup required at contamination sites, and program planning and priority setting reflect the use, value, and vulnerability of the ground-water resource affected by the decision. The underlying rationale for this approach is that not all ground water is of equal value. Distinguishing among classes of ground water will permit the tailoring of protection measures to provide a level of protection that is appropriate to the

current and future use of the ground water. EPA's Strategy defines three classes of ground water:

- Class I – "Special" ground waters — These are geographically limited and are so vital as baseflow to ecologically vital areas or as drinking water supplies that unusually restrictive environmental controls are required for protection. Such controls would go beyond the baseline inherent in EPA's current regulatory programs.
- Class II – Current and potential sources of drinking water and waters having other beneficial uses — These ground waters require the level of protection considered typical in EPA programs. (In a geographic sense, these represent the vast majority of ground water of interest.)
- Class III – Ground water not considered potential sources of drinking water and of limited beneficial use — These are relatively isolated ground waters affected by broad-scale natural or man-made contamination, and which may require less stringent measures to protect human health and the environment.

EPA is currently developing guidelines to assist in classifying ground water under the system presented in the Strategy. The guidelines are to be used by EPA programs in both general and specific decision-making processes. In particular, certain decisions on facility siting, acceptable management, and cleanup will be based on the class (use, value, and vulnerability) of the ground water that may be affected. Guidance will likely deal with facility location, alternative concentration limits, CERCLA feasibility study guidance, leaking underground storage tanks, and special labeling of pesticides that leach.

States need not adopt EPA's ground-water classification for its state program. Where EPA program authority is delegated to the states and a state has a classification that is at least as stringent as EPA's, arrangements will be made so that the state system can substitute. Classification guidelines will be available for public comment later in the year and should be formally issued during 1986.

4. Strengthen Internal EPA Organization

Formation of OGWP: An Office of Ground-Water Protection (OGWP) was established to ensure that the Ground-Water Protection Strategy is implemented and that EPA develops a consistent program approach to ground-water protection. The EPA Regions have also established ground-water offices and coordinating committees. They will coordinate regional ground-water policy and program development and assist the states to increase their institutional capabilities to manage ground water.

Ground-Water Monitoring and Data Management: Monitoring of ground-water quality in the United States is being conducted by EPA, states, federal agencies, such as the U.S. Geological Survey, and the regulated community. These monitoring efforts take place at potential sources of contamination, such as hazardous waste facilities, and at public drinking water supplies as a part of EPA regulatory requirements. In addition, monitoring investigations are conducted to determine the overall quality of our nation's ground water and to identify specific problems, such as pesticides in ground water in agricultural areas.

Even though a large body of information on ground water has developed

over the years, numerous issues exist. These issues result primarily because of the complexity of the ground-water resource; the lack of a clear understanding of those manmade contaminants that we have only recently been able to measure; their treatment and movement in the ground-water environment; and the low priority historically given to the protection of ground-water quality. Because of this combination of factors, as well as the dispersed development of national ground-water protection programs, there has never been a concentrated effort at the federal level to assess the need for ground-water quality data and to plan for its collection, analysis, and use.

The Office of Ground-Water Protection at EPA is developing a Ground-Water Monitoring Strategy to clarify ground-water monitoring objectives and to present a plan for achieving those objectives. The strategy will focus on the decisions that EPA and state and local counterparts must make concerning ground-water quality and the data management and quality assurance necessary to support those decisions.

Looking Ahead

As the problems of ground-water contamination have unfolded and government agencies at all levels have attempted to respond, highly challenging technical issues and public policy questions have emerged. The answers demand more research, information, and technology development. More importantly, they require social decisions on the nature and extent of protection and who should provide for and pay for it.

Technical Issues

The ground-water resource is substantially different from air and surface water. While all air and surface water has a high likelihood of human exposure, this is not true of ground water. Only a very small percentage will ever make human contact. But the manmade chemicals that reach ground water can be present at much higher levels than in surface water.

The rates of movement and mixing of ground water are dramatically different from air and surface water. Ground water moves "glacially," while the Mississippi River drains every five to six days. The accessibility of ground water for monitoring is totally different. Taking a sample involves well drilling and complex procedures, and the information obtained cannot be considered accurate for a point only 10 feet away.

Institutional experience with ground-water management is limited, while there are decades of experience in management of surface waters. The history of manmade contaminants in ground water is yet to be made. Further, there is a major lack of historical data.

The ability of the government to grapple with the activities that cause contamination is vastly more complex than in air or surface water. To prevent contamination of the air, the country must regulate a handful of automobile manufacturers and a few thousand large industries. To protect ground water, tens of thousands of hazardous waste dumps and landfills, hundreds of thousands of surface impoundments, millions of underground tanks, and the use of countless tons of pesticides and fertilizers must be controlled in some way. The potentially regulated community contains not just a few big industries,

but includes small business, individual homeowners, and farmers. No technology exists to preclude contamination from most sources, and the way we use many chemicals must be altered if we are to minimize contamination.

While prevention is complex, cleanup raises even more difficult technical problems. Since ground water moves so slowly, and contaminants adhere to the soils and rocks, additional steps must be taken to prevent the movement of the contaminants into water supplies, to pump out and treat the contaminated ground water, or to treat the water at the tap prior to human consumption. All of these are enormously expensive and not always very effective.

Public Policy Issues

Public policies designed to protect ground water must first recognize the limits of scientific and technical knowledge about the resource as well as the reality that all human activity, no matter how strongly it is controlled, presents some degree of risk to ground-water quality. They must also be designed to take advantage of the statutory and institutional arrangements—federal, state, and local—that are already available to protect ground water. Finally, policies must be flexible enough to encourage scientific and technical advances.

While everyone would agree that the goal is to protect human health and the environment, what that really means in terms of what should not be done to the resources is subject to many interpretations. Some argue that no degradation of the ground water should be allowed. Others, recognizing that human activity may result in some contamination, argue that the ground water should be protected to some finite level (such as a drinking water standard, since the highest use of ground water is as a source of public water supply).

These standards—nondegradation and limited degradation—can be applied to all ground water equally, as is the policy in some states, or they can be applied differentially based on factors such as the use and value of the ground water and its vulnerability to contamination. Proponents of the differential protection approach, which has been adopted by EPA and a number of states, argue that not all ground water is the same. Some is potable and should be protected for drinking. Other ground water is highly saline or otherwise unusable and may not require the same degree of protection measures or cleanup. Control programs under the differential protection approach are tailored to provide greater protection where needed and to reduce the costs of protection and cleanup where less will not present a threat to human health or the environment.

A second major policy question is determining appropriate federal, state, and local roles. The federal government currently has authority to control many activities and contaminants that affect ground water (e.g., hazardous waste sites, pesticides use). It also performs or supports a substantial amount of research and information gathering and provides technical and financial assistance to states. States have the principal role in the protection of the resource primarily due to history, sovereignty, and the diversity of the hydrogeology. Local governments have powerful public health and zoning authorities that may be used for ground-water protection.

A third major public policy issue is: Who pays for all this? Under the various national environmental laws, the federal government has responsibility for regulating certain hazardous substances and activities and for the cleanup of abandoned hazardous waste facilities through a tax on the chemical industry.

Individual industries assume responsibility for prevention costs associated with regulatory programs. States have filled in many areas with monitoring and regulatory controls and in a few cases have adopted cleanup programs of their own. But what of the rest? Should the user (individual land owners or public water suppliers) assume responsibility for damage recovery through private suits or through mandatory insurance or bonding provisions? Should the public, through government control and cleanup, bear parts of the cost? And how much is society willing to spend?

Ground-water protection presents a major challenge to the nation. The scientific and technological issues are vastly complex. The costs of detection, prevention, and cleanup are orders of magnitude higher than for other environmental problems. The ability of federal government to manage the resource for its intended uses is more difficult and more controversial than for air and surface water. New understanding and new ideas are needed to achieve a workable and publicly accepted approach. The public dialogue on these issues has begun in earnest.

MARINE AND ESTUARINE PROTECTION

Valuable natural resources of the United States lie within the nearshore and offshore regions of the oceans defined by the coastal zone, 200-mile fishery conservation zone, and the Exclusive Economic Zone (EEZ) proclaimed by the President in 1983 (Figure 2-11). Oceans and coastal waters provide sources of food, oil, and minerals (products), and are utilized for waste disposal, recreational activities, and as a means of transportation (services). It is estimated that more than 75 percent of the U.S population will live within 50 miles of the coastline by 1990. The associated development is expected to put increasing stresses on the ocean and coastal ecosystems. As economic activities increase along our coasts and in the ocean, conflicts or interactions become inevitable, such as whether to preserve a wetland or permit recreational development.

Assessing the impacts of multiple marine resource use conflicts from man's activities and pollutants on the quality of marine waters is a formidable task. Improved information on the impacts of economic activities, including ecologic effects of pollutant discharges, will be necessary for the resolution of these resource use conflicts. Continued research and monitoring is necessary to identify potential conflicts among ocean uses and users and to obtain optimum economic yield from our natural resources, while preserving the integrity of coastal and marine environments.

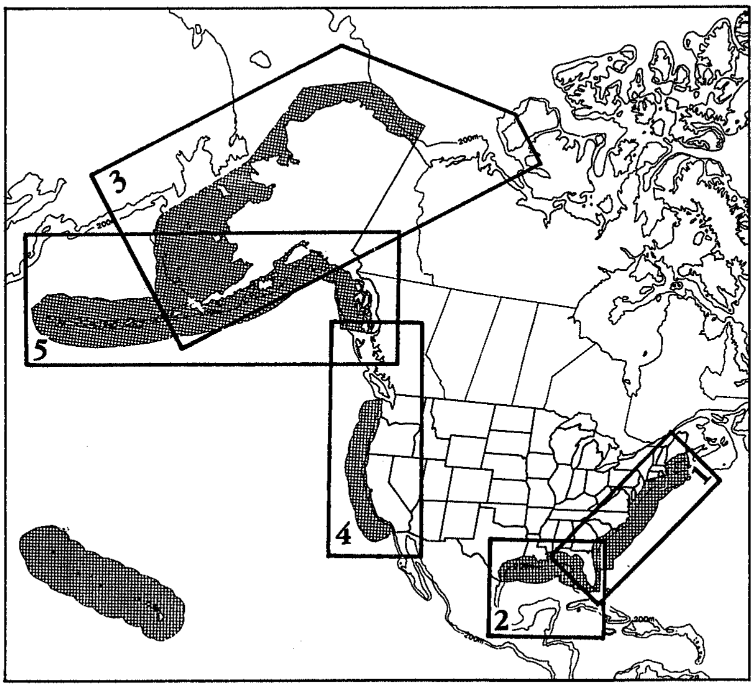
Coastal and Marine Habitat Protection Programs

Valuable coastal and estuarine habitats are threatened by a variety of human activities. Direct physical human impacts on wetlands include dredging and filling activities, construction of coastal structures, such as levees and seawalls, mining of wetland soils, and damage from crop production and mosquito control. Indirect human impacts include sediment diversion by dams and other structures, and hydrologic alterations by canals, spoil banks, and roads.

Section 404 of the Clean Water Act provides the authority for federal involvement in regulating activities that affect wetlands. Under Section 404, the

FIGURE 2-11

REGIONS OF THE
U. S. EXCLUSIVE ECONOMIC ZONE



SOURCE: Department of Commerce, National Oceanic and Atmospheric Administration, Strategic Assessment Branch.

U.S. Army Corps of Engineers evaluates impacts of proposed development projects on wetlands. EPA, National Marine Fisheries Service (NMFS), and Fish and Wildlife Service (FWS) review permit applications submitted to the Corps and provide comments and recommendations on whether permits should be issued. The current Corps wetland research program has three main priorities: (1) develop improved and standardized techniques for identifying wetlands, (2) assess and quantify wetland values for use in evaluating permit activities, and (3) develop techniques for wetland restoration.

NMFS and FWS are federal agencies with legislative responsibilities for fish and wildlife resources and their habitat. Both agencies have common interests in some marine resources and their habitats in coastal waters, estuarine areas, and waters occupied by anadromous fish. NMFS has mandated responsibilities for anadromous fish, commercial fresh water fish, certain species of marine mammals (whales, dolphins, seals, and sea lions), and endangered or threatened marine species, including sea turtles when in the water. FWS-mandated

responsibilities include migrating waterfowl, anadromous fish, resident freshwater fish, certain species of marine mammals (manatees, polar bears, sea otters, and walruses), and sea turtles when they come ashore.

NMFS conducts laboratory and field research investigations on the environmental requirements of living marine resources for reproduction, growth, and other ecological parameters and on the impacts of human activities on marine habitats. The *NMFS Habitat Conservation Program* is designed to develop methods for assessing the viability of fishery stocks and habitats and for understanding and predicting the effects of man's physical activities on coastal ecosystems.[77;78] In addition to these field and laboratory studies, a major effort is currently underway by NMFS in cooperation with the Strategic Assessments Branch of the Ocean Assessments Division (OAD) of NOAA to develop estimates of the current status and trends of coastal and estuarine fishery habitats.

The FWS Coastal Habitat Program[79] is designed to determine changes in important fish and wildlife habitats and to minimize the impacts of development on coastal fish and wildlife resources and their habitats. New approaches have been developed by FWS for coastal habitat characterization, and a major mapping effort is underway. Special emphasis is placed on potential impacts on coastal birds, endangered species, and high-value habitats.

Exclusive Economic Zone Research Programs

NOAA conducts a continuing, comprehensive program of assessment activities, including research, development, and monitoring of the short- and long-term effects of human activities on the marine environment. These activities result in information products and services useful for planning and decision-making related to the resolution of multiple resource-use conflicts, including environmental quality problems, in the estuarine, coastal, and oceanic areas of the United States.

The Strategic Assessment Branch (SAB) maintains comprehensive national inventories of coastal and oceanic resources and their existing and proposed uses, and maintains an operational capability with which to evaluate the environmental and economic effects of national policies and management strategies affecting these coastal and oceanic resources. Data for the entire U.S. are being compiled in computer-accessible files on consistent scales of time and space in order to facilitate the systematic and comprehensive analysis of potential multiple resource-use conflicts within a region and the comparison of resource distributions and uses among regions.

A major effort has been made to collect and synthesize information on the spatial and temporal distribution of about 300 living marine resource species of commercial, recreational, subsistence, or ecological value. This data base is currently operational for the East Coast and Gulf of Mexico portions of the EEZ and will be finished for the Arctic by the end of 1985. The combined information on species' life history and abundance helps to identify those areas of the EEZ that are relatively important biologically.

Gulf of Mexico and East Coast components have also been completed for the *National Coastal Pollutant Discharge Inventory* for which existing information on each coastal and offshore source of water pollutant discharge has been compiled. The types of water pollutants considered include (1) oxygen-demanding materials, (2) nutrients, (3) heavy metals, (4) petroleum hydrocarbons;

(5) synthetic organics, (6) sludges, and (7) pathogens. Source categories include all point, nonpoint, and riverine sources in the coastal zone and EEZ.

As a first step toward the systematic analysis of resource-use conflicts in estuaries, the SAB initiated a major project in FY 1984 to: (1) identify and specify the physical and hydrologic boundaries of all large and medium-sized estuaries in the nation and (2) develop a data base on their important physical and hydrologic characteristics. This project will generate an atlas with maps containing all significant estuaries in the continental U.S. and depicting the boundaries of the estuarine portions of drainage basins, the approximate boundaries of the tidal-fresh mixing-zone and sea water portions of each, and important physical and hydrologic data for each estuary.

The SAB has also been developing and producing a series of five data atlases of important regions of the EEZ: (1) the East Coast; (2) the Gulf of Mexico; (3) the Bering, Chukchi, and Beaufort Seas; (4) the West Coast; and (5) the Gulf of Alaska. These atlases present information on the spatial and temporal distribution of selected characteristics of each EEZ region including: (1) physical environments, (2) living environments, (3) the life histories of living marine resources, (4) coastal and offshore economic activities, (5) marine environmental quality, including pollutant discharges, and (6) jurisdictions. The second volume in the series, the *Gulf of Mexico Data Atlas*, composed of over 170 maps, was published during fiscal year 1984. This data atlas includes the latest synoptic data from oceanographic satellite imagery, such as sea surface temperature maps showing the highly variable nature of the Loop Current in the Gulf of Mexico and chlorophyll *a* maps of the entire Gulf of Mexico region from the Coastal Zone Color Scanner. The Gulf of Mexico Atlas facilitates the combination of different data sets so that visual associations can be made among different characteristics. Computer manipulation of the original data bases is also possible and permits these associations through the use of computer graphics.

National Status and Trends Program

In fiscal year 1984, OAD initiated a new program, the National Status and Trends (S&T) Program, to establish and maintain the information base required to quantify the current status and long-term temporal and spatial trends of key contaminant concentrations, water quality parameters, and biological indicators of environmental quality in the nation's coastal and estuarine environments. The key questions this program intends to answer are (1) what are the current conditions of the nation's coastal zone? and (2) are these conditions getting better or worse? A nationally uniform set of measurement techniques will be employed to determine marine environmental quality parameters. In conducting the program, NOAA is cooperating with and acquiring data from other existing monitoring programs to enhance its assessment capabilities. The S&T Program has four major components: (1) benthic surveillance, (2) mussel watch, (3) water quality, and (4) historical data base development.

The 50 sites along the coastal U.S. selected for *benthic surveillance* include urbanized, industrial areas and a few pristine areas that will serve as reference points. Both sediments and the bottomfish population are sampled at the three stations occupied at each site. Surface sediments are analyzed for major and trace elements, polynuclear aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), chlorinated pesticides, coprostanol (a microbial sewage tracer),

grain size, organic carbon, and carbonate. Widely distributed bottomfish that consume benthic and epibenthic invertebrates are also collected at each station using otter trawls. Necropsies are performed on at least 10 individual fish from each of two species, and visible lesions are noted and tissues preserved for subsequent histopathological examination. A variety of histopathological disorders will be reported on for each age group for each of the species.

For the *mussel watch* component of the S&T Program, mussels and other suitable bivalves are collected from 150 sites nationwide—37 of these stations coincide with sites occupied by the former National Mussel Watch Program supported by the EPA from 1976 to 1978, and several sites are located within National Estuarine Sanctuaries. Tissues from the mussels are analyzed for major and trace elements, PAHs, PCBs, chlorinated pesticides, size, weight, gonadal/somatic index, and percent lipids. The bivalves are also examined for visible and histopathological disorders. Surficial sediments from depositional areas near each mussel watch site are collected and analyzed for the same group of toxic chemicals. Sediments serve as longer term integrators of contaminants and their sediment analysis will aid in the assessment of long-term contaminant status and trends in the sampling areas.

The *water quality* component is an outgrowth of NOAA's Northeast Monitoring Program (NEMP), conducted since 1980 by the National Ocean Service and the Northeast Fisheries Center of the National Marine Fisheries Service. The geographic focus of the Water Quality component is on the U.S. Atlantic Coast, from Block Island, Maine, to Cape Hatteras, North Carolina. The primary objectives of the project are to monitor the annual cycle of pycnocline development and associated reductions of dissolved oxygen levels in bottom waters of the New York Bight/New Jersey shelf and to collect ancillary physical, chemical, and biological data to aid in understanding the processes that may contribute to coastal eutrophication and hypoxia.

NOAA is also developing a Quality Assurance (QA) Program. All laboratories participating in the S&T Program are expected to adhere to requirements, guidelines, and procedures defined by the QA Program. Laboratories supported by other NOAA programs that conduct field measurements of the type described above also will be required to adhere to the QA Program. The QA Program is administered as an integral part of the S&T Program and focuses on the following types of measurements:

- Toxic organic chemicals in sediments, tissues, and the water column;
- Toxic trace metals in sediments, tissues, and the water column;
- Water quality parameters (e.g., chlorophyll, inorganic nutrients, and dissolved oxygen in the water column); and
- Visible and histological pathologies in marine fishes, shellfish, and crustacea.

Another important component of NOAA's S&T and QA programs is the development of methods for preserving and *archiving* biological and environmental samples for retrospective analysis in the future. During fiscal year 1984, OAD initiated a collaborative project with the National Bureau of Standards (NBS) to provide expertise in specimen-banking and to preserve valid samples for extended time periods. The joint NOAA/NBS specimen-banking project will develop and test storage techniques for environmental samples and preserve selected samples from the S&T Program for future analysis either by new methods or for previously unsuspected hazardous chemicals.

Marine and Estuarine Regulatory Programs

Industrial wastes may contain potentially harmful constituents, including synthetic organics, heavy metals, and oil and grease. The primary concern associated with the disposal of industrial wastes is the presence of toxic substances in either a pipeline waste effluent or wastes that are dumped offshore. Much of the industrial waste disposed of in the marine environment is discharged through coastal pipelines, so chemical and biological impacts to nearshore resources are particularly significant.

Federal mandates related to ocean disposal of industrial wastes include the Marine Protection, Research, and Sanctuaries Act (MPRSA), the Federal Water Pollution Control Act (FWPCA), and the Resource Conservation and Recovery Act (RCRA). The MPRSA regulates the transportation and dumping of substances in the ocean (including burning wastes at sea). The FWPCA controls the discharge of pollutants from point sources, and the EPA regulates industry through the National Pollutant Discharge Elimination System under the FWPCA. The RCRA controls, at the federal level, the generation, transport, treatment, storage, and disposal of material classified as hazardous.

Currently several options exist for ocean disposal of industrial wastes. These are ocean dumping, ocean outfalls (pipelines), and at-sea-incineration of hazardous industrial wastes. Each of these activities differs from the others because of the method of discharge, the pollutants in the discharge, the level of treatment prior to discharge, or the regulatory procedure that applies. However, research conducted on marine waste disposal is often pertinent to several disposal options. For example, basic fates and effects studies conducted on a specific pollutant would provide useful information whenever that pollutant enters the marine environment, regardless of the disposal technique used.

The environmental and public health problems associated with hazardous waste disposal have prompted various federal agencies to examine new technologies for treatment and destruction of these materials. High temperature incineration, whether on land or at sea, has been reported as an effective method for the destruction of combustible hazardous wastes.[80] Unlike the case in industrialized European nations, incineration at sea has been conducted only on a limited basis by the United States. However, EPA recently published proposed rules for burning wastes at sea and has several ongoing incineration studies. These activities include development of a research strategy that addresses the technical and operational aspects of incineration at sea and an investigation that compares risks from land-based and ocean-based incinerators.

Several federal agencies support research and/or monitoring programs that focus on the effects of industrial waste disposal. NOAA programs include assessment of the implication of human activities on estuarine and coastal environments and quantify environmental consequences of existing and proposed resource-management and development activities. EPA addresses industrial waste disposal through several programs. The Marine Waste Disposal program was formulated to assist EPA in developing rules, criteria, and standards that are used to regulate industrial disposal activities. The Water Quality Research program includes investigations on the transport, transformation, and fate of toxic materials in the marine environment. In addition, the USFWS conducts research on the effects of contaminants on fishes, and the FDA monitors and assesses

contaminant levels in seafood to assure shellfish are safe for human consumption.

Municipal wastes contain organic material and microorganisms, including pathogens associated with the fecal material, and many other contaminants. Sewage sludge is the end-product of sewage-treatment processes in which much of the suspended solids of raw sewage are collected and concentrated in a slurry of about 5 percent solids and 95 percent water. Ocean disposal of sewage sludge frequently occurs at some distance from shore via ocean dumping to increase dilution of the wastes and reduce contact with man. The disposal of these wastes is regulated primarily under the provisions of the Marine Protection, Research, and Sanctuaries Act and the Federal Water Pollution Control Act.

Several federal programs focus directly on municipal waste disposal or conduct generic pollution studies that have relevance to sewage inputs to the marine environment. NOAA programs include major research projects to determine the effects of municipal waste disposal in the Hudson-Raritan/New York Bight. Other NOAA studies include bioavailability of selected contaminants, development and testing of coastal indices, and studies on current patterns surrounding outfalls for sewage sludge. NOAA also supports research to determine the distribution of microbial human pathogens and particle dynamics of sewage sludge.

The Marine Waste Disposal program in EPA addresses ecological response and spatial/temporal changes of biota to sewage effluents, an analysis of monitoring data from 310(h) permit applications, and the development of general and site-specific site designation protocols for ocean dump sites. The EPA program also includes other projects less directly related to sewage wastes, such as studies of sediment contamination, effects on benthic productivity, and the persistence and fate of pollutants in marine food webs. Within the program of Water Quality Research, EPA performs or supports research on priority pollutants, toxic substances, pesticides, and carcinogens. The results of these studies provide greater understanding of the fate and effects of contaminants released to the environment via sewage disposal. They also provide more complete scientific information to help judge the effectiveness of pretreatment programs, ocean dumpsite designation, the permit review process for ocean dumping, and monitoring program development.

Excavation of new channels and maintenance dredging of existing channels are required to provide safe and efficient navigation areas for commercial and recreational marine vessels. On the basis of volume, dredging is the largest single source of materials that are ocean-dumped. Approximately 58 million cubic yards of dredged material were deposited in an estimated 135 EPA-approved ocean dumpsites in 1983.[81] Of this total, 65 percent was disposed of in the Gulf of Mexico, 22 percent in the Atlantic Ocean, and 13 percent in the Pacific Ocean. In addition, approximately 135 million cubic yards of dredged material from coastal areas per year is disposed of by alternative disposal options such as beach nourishment or upland disposal.[82]

Disposal of dredged material in fresh water and coastal areas is primarily regulated under the Federal Water Pollution Control Act (FWPCA) and the Marine Protection, Research, and Sanctuaries Act (MPRSA). Under Section 404 of FWPCA, EPA is responsible for regulation of dredging activities in coastal areas to the outer boundary of the territorial sea. Title I of MPRSA stipulates that the Department of the Army reviews applications for permits and, when appropriate, issues permits for the transportation of dredged material to ocean disposal sites (Section 103). The Corps of Engineers (COE) has been designated

by the Secretary of the Army to implement this authority. EPA designates ocean disposal sites and develops criteria for dredged material disposal.

Most of the dredged material excavated in the U.S. contains at most only trace levels of harmful pollutants. The primary concerns associated with these relatively innocuous materials are the direct physical effects of disposal. The physical effects include burial of organisms, increased levels of suspended sediments, and accretion of disposed materials.[83] If material is dredged from highly polluted areas it may be contaminated with potentially harmful chemical constituents such as heavy metals, synthetic organics, and oil and grease. Much research has been conducted to describe the effects of dredged material disposal in the marine environment and to evaluate disposal options that may be preferable to ocean dumping. A regulatory process based on research has evolved to evaluate dredged material for disposal options and to designate and monitor disposal sites. To ensure that the best practicable procedures are employed in evaluating applications for ocean disposal of dredged material, the COE and EPA have coordinated to develop a guidance manual for implementing Section 103 of MPRSA.[84] The manual summarizes and describes procedures for ecological evaluation of dredged material before ocean disposal. The COE is also developing a new approach that will provide protocols for evaluating all available disposal options for each dredging project.[85] In addition, COE and EPA have conducted a field verification project to predict impacts from alternative disposal options. COE supports two other research programs related to dredged disposal: the Flood Control Navigation Program, which includes evaluation and development of improved maintenance dredging techniques, and the Environmental Quality Program, which includes research on the long-term effects of dredging operations.

Radioactive wastes are presently accumulating in the U.S., from the many uses of radioactive isotopes. The sources of these wastes include commercial nuclear fuel, defense-related activities, medical and research applications, general industrial uses, and mining and milling of uranium ore. Department of Energy (DOE) projections[86] indicate that by the year 2020 the amount of radioactive waste accumulated will be about four times greater than the currently accumulated amounts. Some of the options being considered for management of these wastes involve disposal or placement in the oceans or burial beneath the oceans, that is, subseabed emplacement. As accumulations of these wastes increase, the ocean disposal of such waste may appear increasingly attractive because it offers a relatively inexpensive means of management that may well pose less threat to the environment and human health than alternative land-based options. However, under present law, the oceans cannot be used for disposal of high-level wastes. Ocean disposal of low-level radioactive wastes is allowed only under permit from the EPA.

The EPA has reviewed the past U.S. practices for ocean disposal of radioactive waste and, with assistance from NOAA and other agencies, has conducted actual field surveys of the major sites where such dumping occurred. This program found little evidence of environmental radioactivity above expected background levels, except in sediments near corroded or imploded containers.[87] Also, EPA, in conjunction with the Food and Drug Administration, initiated a program in 1981 to collect and analyze marketplace fish collected in the general vicinity of dumpsites. No radionuclide concentrations above normal background have been found. The U.S. General Accounting Office[88] reported that, "Evidence

overwhelmingly shows past dumping poses neither an environmental nor public health hazard." The National Advisory Council on Oceans and Atmosphere (NACOA)[89] recommended that the U.S. revise its policy excluding use of the ocean for low-level waste disposal.

Presently DOE has the largest research and monitoring program concerned with ocean-related disposal of radioactive wastes. A large part of their efforts are directed toward developing techniques for subseabed emplacement of high-level wastes and research on the environmental effects of such emplacement.

DOE studies related to low-level waste disposal in the oceans are under three programs—the Regional Marine Ecology Program, the Radioecology Program, and the Physiological Ecology Program. DOE supports general oceanographic studies related to the fates and effects in the oceans of energy-related pollutants, including those arising from disposal of low-level wastes. The goal of this work is to conduct a scientifically sound and comprehensive program of research and assessment to identify, analyze, and reduce health and environmental uncertainties that impede the safe and economical implementation of a broad domestic energy policy.

Only the EPA has a program directed specifically at the problems of management of low-level radioactive wastes. EPA conducts a research and monitoring program directed at obtaining a technical basis to support its mandate for permitting ocean dumping of low-level wastes. The program emphasizes studies to assist in the development of guidelines and criteria for packaging low-level wastes for disposal and for dumpsite designation and monitoring. EPA's program includes compiling what is already known concerning background concentrations of selected radionuclides in sea water, sediments, and marine organisms, as well as the field bioconcentration factors of radionuclides in marine biota that can be derived from their concentrations.

Oil and gas exploration, development, and production on the Outer Continental Shelf (OCS) have potential for adverse marine environmental effects. Marine pollution concerns associated with OCS activities include the effects of chronic discharges of oil, discharges of drilling muds, and pipeline emplacement, especially in sensitive coastal areas (e.g., wetlands). In addition, there is concern about the cumulative effects on marine resources in intensively developed oil and gas exploration areas, such as the Gulf of Mexico. The Minerals Management Service's OCS Environmental Studies Program supports most of the federal research and monitoring related to OCS oil and gas development and is discussed further in Chapter 8.

Sanctuaries, Refuges, and Parks in the Coastal Zone

Designation of marine and estuarine sanctuaries and other restricted use areas in the coastal zone, including national and state parks and seashores, wildlife refuges, and forests, offers some measure of protection for selected portions of coastal habitat and its associated resources from disruption by human activities and pollution. NOAA's Sanctuary Programs Division carries out an active research program within designated marine and estuarine sanctuaries to determine: (1) the capacity of sanctuary resources to sustain use of different types; (2) the importance of the sanctuary environment to rare, endangered, or otherwise important marine species; and (3) the vulnerability of submerged cultural resources, including shipwrecks and other artifacts of historic human occupation or use.

Research programs initiated to address these issues include: (1) establishing and evaluating a baseline picture of the sanctuary through comprehensive resource inventory and mapping studies, and other studies as necessary to improve basic understanding of the ecological structure of the system and the processes of importance to system functions; (2) conducting on-site visitor surveys to establish visitor use patterns and developing management strategies to alleviate visitation pressures; and (3) implementing monitoring programs and conducting experimental research to study the effects of natural and human disturbance on the sanctuary environment. Analogous research is conducted in the Department of the Interior's systems of National Parks and Wildlife Refuges. The importance of these refuges to selected target species, such as marine mammals, sea turtles, and waterfowl is undisputed; in addition, however, the network of protected coastal areas helps to provide habitat suitable for spawning or nursery areas of estuarine and coastal fish and shellfish populations, and to buffer the effects of scattered habitat modification projects and pollution incidents.

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Chapter 3
Hazardous Chemicals

Comprehensive federal regulation of commercial chemical products and chemical wastes became a major undertaking of the U.S. Environmental Protection Agency (EPA) beginning in 1976 with the enactment of the Toxic Substances Control Act and the Resource Conservation and Recovery Act. Until then, only chemical pesticidal products were systematically regulated under the 1972 Federal Insecticide, Fungicide, and Rodenticide Act. (It was also in June 1976 that the "Flannery decision" was rendered in U.S. District Court, District of Columbia, which ordered EPA, under the Federal Water Pollution Control Act, to regulate a long list of "priority pollutants," mostly metals and synthetic organics that were detected in waste water discharges from industry and municipal treatment plants in relatively low concentrations.)

The nation's growing concern over the possible links between exposure to even small amounts of these ubiquitous chemical substances and human cancers has provided the impetus for widening the ambit of federal regulatory control over the chemical industry and the associated handling of hazardous chemical wastes. This chapter explores selected aspects of each of four federal environmental protection programs principally designed to control releases of chemicals into the environment: The Resource Conservation and Recovery Act of 1976, the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, the Toxic Substances Control Act of 1976 and the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) of 1972.

Chemical Wastes: The Hazardous and Solid Waste Amendments of 1984

Establishing the Regulatory Framework

The Resource Conservation and Recovery Act of 1976 (RCRA) established the first comprehensive federal regulatory program for controlling hazardous waste and provided grants and technical assistance to the states to help improve waste management techniques.

Initally, federal efforts focused on establishing the regulatory framework for hazardous waste management. These regulations established standards for identifying and listing hazardous wastes, for generators of hazardous waste, for transporters, for hazardous waste managers awaiting administrative disposition of their permits, and for managers with permits.

Among the most important features of the standards are the following:

- Wastes may be hazardous because they possess certain characteristics (they are ignitable, corrosive, reactive, or toxic) because EPA lists them as being hazardous, or because their generators declare them to be hazardous;

- Firms must identify whether their wastes are hazardous, obtain EPA identification numbers, comply with the manifest system if they send their waste off-site for management, follow "good housekeeping standards" requiring labeling and marking of wastes, and keep records and file biennial reports with EPA;
- Transporters of hazardous waste must obtain EPA ID numbers, comply with manifesting requirements, deliver waste only to the facility the generator selects, and clean up spills or discharges immediately;
- Managers of hazardous waste facilities who are waiting for a final permit (often called Interim Status facilities) must perform good housekeeping, recordkeeping, and reporting activities; obtain EPA ID numbers; prepare and follow closure plans, and where appropriate, post-closure plans; show that they have sufficient funds available to close the facility, provide care following closure for land disposal facilities, and insurance; monitor their ground water if they are land disposal facilities; and comply with technical standards directed at specific waste management practices; and
- Managers of facilities with permits must comply with all of the requirements for facilities without permits; in addition, they must comply with a far more stringent set of technical standards including requiring liners for land disposal facilities, destroying 99.99 percent of the organic wastes in the feedstock for incinerators, and cleaning up ground-water contamination for land disposal facilities.

The scope of this regulatory framework was significantly broadened by Congress through amendments to RCRA that became law in November 1984.

The Hazardous and Solid Waste Amendments of 1984

A major theme of the Hazardous and Solid Waste Amendments of 1984 (HSWA) is the protection of ground water through the following requirements:

- New technological standards for land disposal facilities (double liners, leachate collection systems, ground-water monitoring);
- New requirements for the management and treatment of small quantities of hazardous waste, such as those generated by auto repair shops or dry cleaners;
- New regulations for underground tanks that store liquid petroleum and chemical products;
- Upgraded criteria for disposing of municipal solid waste in landfills;
- Restrictions on the future land disposal of many untreated hazardous wastes.

Ground water is increasingly seen as a vulnerable resource because it is used so widely for drinking water and, once contaminated, is extremely costly to cleanse. According to the U.S. Geological Survey, ground water provides approximately 50 percent of the drinking water and 20 percent of all water used in the United States.[1]

The precise scope of ground-water contamination is not known, but data collected by EPA in its Superfund and RCRA programs, and obtained from testing public water supply wells, suggest that a problem exists nationwide. Of the almost 800 contaminated sites EPA has targeted under Superfund for remedial action on its "National Priorities List," approximately 75 percent pose

a threat to ground water.[2] The problem potentially affects some highly populated areas: for example, near Atlantic City, New Jersey; Tacoma, Washington; and Miami, Florida.

In addition to measures to protect ground water from chemical contamination, the 1984 RCRA amendments brought several other waste disposal activities under federal regulatory control, for example, the blending of hazardous wastes with fuels that fire industrial or commercial boilers.

The following sections discuss the major new chemical waste control programs authorized by the Congress in 1984.

New Restrictions on Land Disposal of Wastes

Perhaps the most significant aspect of the 1984 HSWA is the severe restrictions it places on the treatment, storage, and disposal of hazardous wastes in land management facilities.

Land disposal has been a dominant hazardous waste disposal alternative, in part because it has been less expensive than incineration, neutralization, stabilization, or other non-land based options. Also environmental statutes, for example, the Clean Air Act, which place stringent controls on air emissions and thus on incineration, have encouraged land disposal of hazardous waste. However, the true costs of land disposal often have not been fully borne by the generator or disposer of the wastes. Land disposal of hazardous waste contaminates ground and surface waters, resulting in possible adverse human health effects, closure of drinking water wells, displacement of communities, and occasional fish kills.

EPA also identified the distribution of the 55 million metric tons of hazardous waste *disposed* of in the year examined in the study (1981), by type of process. This distribution is illustrated in Figure 3–1. Forty-two percent is disposed on land surfaces.

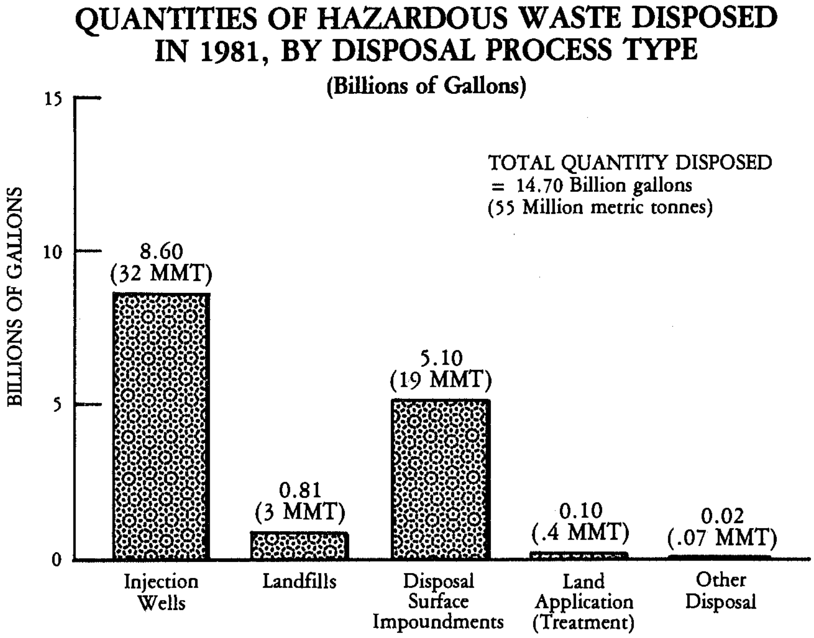
An April 1984 EPA study indicated that the total amount of hazardous waste *generated* in the United States had previously been underestimated. Whereas an earlier estimate was approximately 41 million metric tons per year, a more recent projection estimates 264 million metric tons.[3]

Hazardous Waste Facilities

To address the public health and environmental problems posed by land management of hazardous wastes, the 1984 law establishes a strict schedule for determining whether to phase out land disposal of untreated hazardous waste between 1986 and 1990, and creates new and more stringent requirements for land disposal facilities that now exist and for those that will be created to deal with the residue of wastes that will require land disposal. It creates a rigid schedule for the review of all hazardous waste and automatically restricts the land disposal of a particular waste if EPA has not, within a set timeframe, made a determination that land disposal is safe. EPA has scheduled dioxin and certain widely used solvents for early review, with final determination by November 1986.

The statutory restrictions on land disposal reflect the concern that, even with more stringent controls in permitted land disposal facilities, all land disposal facilities, even under the best conditions, may eventually leak. Two prominent

FIGURE 3-1



SOURCE: U. S. Environmental Agency, "National Survey of Hazardous Waste Generator and Treatment, Storage, and Disposal Facilities Regulated under RCRA in 1981" prepared by Westat, Inc., p. 205.

examples are the BKK Landfill in Southern California and the Cecos facility in Niagara, New York. The BKK facility was considered to be a "state-of-the-art" disposal facility. It was closed to hazardous waste disposal in 1983 because contaminated ground water was found near the site; the Cecos facility continues to operate, but under close scrutiny because contaminated ground water has also been detected nearby.

Surface impoundments containing hazardous wastes will be subject to the stringent minimum technological requirements for land disposal units, which include the installation of two or more liners and a leachate collection system plus ground water monitoring. Operators of existing hazardous waste surface impoundments will have to meet these requirements, cease operation, or seek a waiver.

The law discourages the disposal of hazardous wastes in underground injection wells, land treatment facilities, and waste piles, as they pose potential dangers to ground water supplies. The new law requires that underground injection of hazardous waste be prohibited within 1/4 mile of a drinking water source. By August 1988, EPA must decide whether to ban underground injections of dioxins, certain solvents, and other hazardous wastes.

Nonhazardous Facilities

While the primary focus of the expanded program is safe management of

the approximately 5,000 facilities authorized to treat, store, or dispose of hazardous waste, there is increasing concern for dealing with the problem of ground water contamination from the active nonhazardous waste disposal facilities in the U.S. A 1979 EPA study estimated that there were 275,000 such facilities, including 181,000 surface impoundments, 18,500 municipal waste landfills, and 75,700 industrial waste landfills (not authorized to process hazardous wastes). There were also an unknown number of other land treatment units receiving food, textile, tannery, and pharmaceutical wastes, and wastewater treatment (sewage) sludge.[4]

Surface impoundments include ponds, pits, and lagoons, or shallow excavated depressions in the ground above the water table. They can be used to separate chemical wastes, solid wastes, and water through evaporation. In some cases they are used for disposal, temporary storage, and treatment of industrial wastes.

Another type of land disposal activity was the subject of legislative and regulatory concern in 1984 as a source of ground water contamination — the so-called sanitary or municipal landfill (Subtitle D facility). These facilities are not authorized to accept hazardous waste under the RCRA program, but because household chemical wastes (cleaning products such as oven cleaner, paint thinner, garden insecticides) and the wastes from small quantity generators have been exempt from federal regulatory controls, these wastes have usually been disposed of in such landfills.

Congress has enacted new mandatory federal controls on nonhazardous (Subtitle D) waste landfills. After a thorough review of the existing data on municipal landfills, EPA must issue by March 1988 new criteria for facilities that may receive hazardous household wastes or hazardous waste from small quantity generators. The criteria must be protective of human health and the environment and may take into account the practicable capability of such facilities. Such revisions could require ground water monitoring, siting standards, and actions to be taken if some type of release occurs. By September 1989, states will have to establish a permit program for facilities that receive hazardous household waste and waste from small quantity generators. If a state fails to enforce the program, the federal government is granted enforcement powers. Previously, the nonhazardous waste provisions simply called for a voluntary program for managing nonhazardous waste/municipal landfills.

Small Quantities of Hazardous Waste

Heretofore the federal government did not regulate most waste management practices of certain small businesses, local governments, hospitals, and other small quantity producers of hazardous waste. Under the 1984 Amendments, however, EPA is required to include "small quantity generators" in the federal hazardous waste management program. Small-quantity hazardous waste generators might typically include gas stations, auto paint and repair shops, photography studios, printing shops, dry cleaners, and metal manufacturers. Those establishments that generate more than 100 but less than 1,000 kilograms of hazardous waste per month will now be subject to additional federal regulation. This amount is equivalent to 200 to 2,200 pounds per month or roughly half of a 55-gallon drum.

Estimates of the number of small-quantity generators and the total hazardous wastes they produce vary. The Congressional Office of Technology

Assessment (OTA) has placed the amount at up to 10 percent of all hazardous waste generated.[5] A study by EPA in 1984 suggests that such wastes make up less than 1 percent of all the hazardous waste generated, and are produced by approximately 630,000 establishments. This number includes establishments generating less than 1,000 kilograms per month. EPA estimates that there are 100,000–175,000 generators of hazardous waste producing between 1,000 and 100 kilograms per month (kg/mo). Prior to 1984, the EPA regulations covered only about 14,000 "large quantity" hazardous waste generators.[6]

The 1984 EPA survey produced the following profile of those small quantity generators that produce between 100 and 1,000 kg/mo:

By Activity[7]

Vehicle maintenance	70%*
Construction	3%
Other non-manufacturing	13%
Metal manufacturing	9%
Other manufacturing	5%
Total	100%

By Waste Produced[8]

Lead-acid batteries	62%*
Solvents	18%
Acids and alkalies	6%
Photographic wastes	3%
Ignitable wastes	2%
Dry cleaning residues	2%
Other	7%
Total	100%

* Only about 10 percent of the spent lead acid batteries shipped off-site are not recycled. Recycled lead acid batteries are not subject to RCRA hazardous waste regulations.

Hazardous waste from small quantity generators can pose a danger to public health and the environment, if disposed of in improperly designed or poorly managed sanitary municipal landfills, which may leak. Prior to 1980, hazardous wastes were legally accepted by many municipal landfills — a practice that has since been prohibited. (A number of sites on the Superfund National Priorities List were used as municipal landfills or local dumps.) It is seldom possible to determine the exact source of contamination when wastes from both large and small quantity generators have been disposed of in a municipal landfill.

Improper packaging and labeling of hazardous wastes produced by small quantity generators may also pose a danger to transporters. These wastes may be toxic, explosive, or have a corrosive effect upon the containers and the vehicles used to transport them.

Recognizing the health and environmental threats posed by hazardous wastes produced by small-scale generators, 15 states — California, Illinois, Kansas, Louisiana, Maine, Maryland, Massachusetts, Minnesota, Missouri, New Hampshire, New Jersey, Rhode Island, South Carolina, Vermont, and Washington — had previously enacted regulations for disposal of such substances. Some states make no distinction between large quantity generators and small quantity generators.

The 1984 law places new federal requirements upon small quantity generators. After August 1985, small waste generators will be required to complete parts of the uniform hazardous waste manifest used for shipment of hazardous wastes. As early as April 1986, small quantities of hazardous waste can be treated, stored, and disposed of only in authorized hazardous waste facilities. No small quantity generator will be able to store waste on the establishment's premises for more than 180 to 270 days without a permit.

Leaking Underground Storage Tanks

The Office of Technology Assessment (OTA) has estimated that there are over 2.5 million tanks containing liquid petroleum products and chemical substances buried underground.[9] Underground storage tanks of gasoline are located at convenience stores, mass merchandisers, general stores, and service stations. Federal and state governments as well as local municipalities store fuels in underground tanks, as do mass transit authorities, manufacturing plants, military bases, hospitals, schools, car rental agencies, and some homeowners. While tanks can leak because of deterioriated piping, ruptured hoses, and physical breakage, corrosion appears to be the major cause of tank leakage.

Leaks from underground storage tanks can contaminate soils, ground and surface waters, and can cause explosions and fires. They can damage sewer systems and treatment plants and disrupt businesses and homes when the leaking product or its vapors enters buildings. A study of ground water protection published in 1984 by the General Accounting Office (GAO) found that incidents of ground-water contamination from leaking underground tanks have occurred in all 50 states.[10]

The 1984 amendments establish a new federal regulatory program to prevent health and safety problems resulting from leaking underground storage tanks. This is the first time that RCRA has been extended to cover potentially hazardous *products*; previously the law was restricted to hazardous *wastes* only. The new law prohibits, after May 1985, installation of underground tanks without protection against corrosion and creates a tank notification/registration program for all underground tanks. The law also requires EPA to issue federal standards for new underground petroleum and chemical substance tanks by February 1987.

EPA has been given responsibility for: (1) issuing the standards for the design, construction, and installation of new tanks by manufacturers and installers, and (2) developing criteria for programs that are the responsibility of operators for the prevention, detection, and correction of leaks. The states, meanwhile, have been given the major responsibility for the notification/registration program. Governors were to have designated the state agency/contact to receive the tank notifications by May 1985. EPA will determine the general information to be

gathered in the notification program — such as tank age, size, type, uses, and location. The states have the responsibility of developing the notification form, distributing it, and gathering the information.

Some tanks have been excluded by Congress from the underground tank regulatory program. Examples include: farm and residential tanks storing less than 1,000 gallons of motor fuel (for noncommercial purposes); tanks used for storing heating oil for use on the premises where they are stored; septic tanks and sewage collection systems; pipelines used in the production and transportation of gas and oil; and storage tanks located in an underground area (such as a basement or cellar) if the tank is on or above the floor's surface.

Hazardous Waste-Fuel Mixtures

The 1984 amendments require the EPA to develop standards prior to November 1986 governing the burning of hazardous waste-fuel mixtures. Until 1984, there had been no federal regulatory control on burning hazardous waste and used oil in boilers and industrial furnaces.[11]

Burning hazardous waste and used oil as fuel may result in hazardous emissions that damage human health and the environment. One of the best-documented incidents occurred at a facility in New Jersey owned by Quanta, a used oil fuel-blending concern. The firm accepted contaminated used oil, including PCB-contaminated transformer oil, as well as other hazardous wastes, including chlorinated solvents.

PCBs, which are persistent in the environment because they do not readily break down into less harmful chemicals, were banned by EPA in 1976. Acute and chronic exposure to PCBs can cause liver damage and has caused cancer in laboratory animals. Chlorinated solvents include carbon tetrachloride and trichloroethylene (TCE), both used as degreasers and dry cleaning agents.

"Treatment" of the tainted oil at the Quanta facility was typical of that used in the industry. It consisted of settling out bulk solids and water only. Contaminants were not removed or neutralized.

The blended mixture was marketed as a fuel, sometimes to retail fuel distributors, and sometimes sold directly to industrial and residential users. In 1981 ABC News' investigators filmed trucks taking contaminated commercial fuel oil from Quanta to apartment buildings in New York City. Residents of those buildings complained of respiratory problems, headaches, nausea, and digestive problems shortly after these fuels were burned. Boiler residues at these buildings, when analyzed, showed the presence of PCBs and chlorinated solvents.

EPA's best estimate is that about 1–2 million tons of hazardous wastes and about 2.4 million tons of used oils are burned annually as fuel.[12]

The major risk in burning waste fuels comes from exposure to the emissions of toxic chemicals and toxic metals. Used oils, for example, frequently arrive at a fuel processing or blending facility heavily contaminated with organic and inorganic toxic material, including toxic metals such as arsenic, chromium, and lead, as well as chlorinated organic contaminants.

Without proper labelling of waste fuels, burner operators do not know that they are storing and burning a potentially dangerous fuel. The residue from burning waste fuels could be heavily contaminated with hazardous wastes, toxic

metals, or toxic combustion by-products that were not destroyed during combustion. This residue would likely not be treated as a hazardous waste and may be disposed of in a municipal landfill. Waste fuels also may cause harm if they are misdirected or dumped illegally.

Currently, processors and blenders of used oil or hazardous waste have no incentive to remove these potentially harmful contaminants. Product price is typically related only to a fuel's BTU specification and its viscosity. Technologies that remove metals and other contaminants do exist, such as distillation or chemical treatment; however, processors who use these technologies often find themselves at a competitive disadvantage to those who only filter, settle, and blend. Thus, Congress concluded that regulatory controls over the composition of waste fuels were necessary.

In January 1985, EPA proposed a regulatory program for burning and blending that would focus on small, nonindustrial boilers, which account for 98 percent of commercial and institutional boilers and virtually all residential boilers. These typically have the capacity to service an area equivalent to a large hospital or large apartment or office building (190,000 square feet). The limited combustion controls on such small boilers make it very difficult to maintain maximum combustion efficiency. This means they do not destroy toxic substances completely.

Nonindustrial boilers are not subject to the same degree of zoning control as are industrial facilities. Rather, they are typically located in densely populated urban areas, where they may pose a risk from spills, fire, and explosion resulting from transportation, storage, handling, and burning of tainted fuels.

The 1984 amendments require that by February 1985 all producers, distributors, and marketers of hazardous waste fuels place a warning label on the invoice or bill of sale indicating that the fuel contains hazardous waste and listing the waste. The new law also requires that by November 1985 burning/blending facilities notify the EPA of their activities and provide the location of the facility, a description of their operation, and the names of the hazardous wastes involved. After February 1986, these facilities will be required to keep records of their activities. The EPA is also mandated to develop standards for transporters of hazardous waste fuels and the facilities that burn the fuel.

Chemical Wastes: Superfund — EPA's Hazardous Waste Cleanup Program

Perspective: Before Superfund

Before there was any federal legal authority to address problems caused by hazardous substance contamination, cleanup was taken on an *ad hoc* basis as problems arose. Most spills, such as from an overturned chemical tank truck or a ruptured pipeline, were cleaned up by private parties, usually the owners or operators involved. Responsible parties still conduct the great majority of spill cleanups. When responsible parties did not clean up a spill, state and local governments were sometimes able to respond, often through state police or local fire departments. State and local government resources for responding to spills varied widely. State funds were rarely available for more expensive,

long-term cleanups at, for example, abandoned dump sites. Not only were state funds usually unavailable, most states lacked specific legal authority to compel responsible parties to undertake long-term cleanups.

The first limited federal authority for responding to hazardous substance problems was provided by the clean water act (CWA), as enacted in 1972, which enables the federal government to take action when a designated hazardous substance, or oil, is discharged into navigable waters. But CWA does not authorize response when hazardous substances or oil are discharged anywhere else in the environment. Further, CWA focuses on taking action for discharges that present an "imminent and substantial danger" to the public health or welfare; that is, emphasis is on short-term emergency cleanups. The total size of the cleanup fund established under CWA, $35 million, is inadequate for the number of sites with more extensive contamination.

The Resource Conservation and Recovery Act of 1976 (RCRA) establishes a system to track hazardous wastes from the time they are generated until they are disposed and requires that all facilities that treat, store, or dispose of hazardous wastes obtain permits to operate. RCRA authorizes the federal government to order responsible parties to take cleanup action in emergency situations. But when such parties do not take appropriate action, there is no provision in RCRA that allows the federal government to respond. RCRA focuses on preventing hazardous substance problems, not on cleaning them up.

Several other federal laws, such as the Clean Air Act, give the government similar legal authority to require responsible parties to take cleanup action when necessary, but do not authorize direct federal response. In some situations, a long legal battle may prevent action from being taken when it is needed. In other cases, such as when the owners of a site cannot be located or are financially unable to clean up a site, legal action could be ineffective, and federal response may be the best option.

Development of Public Awareness of the Hazardous Substance Problem

Problems caused by hazardous substance disposal have received widespread public notice only within the last 10 to 15 years. Fourteen years ago, CEQ's second annual report devoted only one paragraph to waste disposal, in which it notes the start of an EPA program to close 5,000 of "the approximately 15,000 open dumps in the United States." The report does not mention the need to respond to any problems caused by these dumps.

Several incidents in the late 1970s, after a 25-year period of steadily increasing production of industrial chemicals, helped make the public and Congress aware of the potential dangers of large-scale disposal and handling of hazardous substances. On February 26, 1979, a railroad freight car carrying 90,000 pounds of chloride gas punctured near Youngstown, Florida, killing eight people on a nearby highway, injuring 183 others, and forcing the evacuation of 3,500 residents. On April 21, 1980, a fire broke out at the Chemical Control facility, an inactive waste treatment company in Elizabeth, New Jersey. Tens of thousands of drums were stored at the site containing various toxic and corrosive substances, including pesticides, explosives, and radioactive wastes. The fire released clouds of toxic smoke that narrowly missed large residential areas one-quarter mile from the site.

More than any other incident, events at the Love Canal site in Niagara Falls, New York, sparked public concern about hazardous substances. Hundreds of tons of toxic wastes were dumped in the unfinished canal in the 1940s and 1950s; the canal was covered, and houses and a school were built on top and surrounding it. Concern about health problems in residents at the site prompted the evacuation in 1978 of several hundred residents. A long-term cleanup has not yet been completed.

These incidents and others pointed out the need for a mechanism to respond both to emergency situations and to more long-term dangers created by hazardous substances. At many sites, the companies responsible for problems associated with past disposal of hazardous wastes have gone out of business or do not have resources adequate to respond. Further, state funds for hazardous substance cleanup before the last few years were practically nonexistent. Superfund was the option decided upon to address this problem.

Superfund: Responding to the Hazardous Substance Problem

Public concern about the incidents described above was part of the impetus for passage of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA or Superfund).[13] CERCLA was passed in December 1980 to fill the gaps left by other environmental laws. The purpose of CERCLA, stated in the law, is

> To provide for liability, compensation, cleanup, and emergency response for hazardous substances released into the environment and the cleanup of inactive hazardous waste disposal sites.[14]

The Superfund program, which is managed by the Environmental Protection Agency (EPA), allows the federal government to respond to any release or substantial threat of a release of a hazardous substance into the environment, and established a $1.6 billion fund to pay for response. The fund, which is more than 40 times as large as the cleanup fund under CWA, is financed primarily by an excise tax on the sale or use of petroleum and 42 chemicals that are used commercially to produce hazardous substances. Some fund money, $44 million annually, comes from general tax revenues.

CERCLA incorporates a few mechanisms of the Clean Water Act, including authority to respond in emergency situations, but it provides much greater authority to address the problems caused by disposal and spills of hazardous substances. In addition to the emergency response provisions, CERCLA adopts two major CWA components:

- Publishing a list of designated hazardous substances and setting reportable quantities (RQs) for these substances. A release equal to or exceeding the RQ of any designated hazardous substance must be reported to the U.S. Coast Guard's National Response Center. Reports of hazardous substance releases are one way EPA becomes aware of situations where a Superfund response action may be needed. The CERCLA list initially included 696 substances, each of which was assigned an RQ of 1, 10, 100, 1,000, or 5,000 pounds. Many of these substances were assigned a 1 pound RQ by CERCLA pending any necessary adjustment by EPA. In 1983 EPA

proposed adjusted RQs for 387 substances, and is evaluating the remaining substances for possible RQ adjustment.

- Using the National Contingency Plan (NCP) to establish procedures that must be followed by EPA and others in responding to releases of hazardous substances, CERCLA required EPA to revise the NCP regulations, which were originally established under CWA, to reflect EPA's expanded responsibilities under CERCLA. The NCP provides the basic operating guidelines for the Superfund response program and is the document through which the statutory response authorities of CERCLA are translated by EPA into regulation.[15]

Unlike CWA, however, CERCLA allows the federal government to respond to any releases into the environment, not just releases that affect navigable waterways. Therefore, EPA can take action at a leaking dump site, for example, that is a threat to a nearby residential area located far from a coastline or a large river. CERCLA allows EPA to take action not only in emergency situations but also at sites that present long-term hazards and that require more complicated cleanup action, such as at the Love Canal site. Finally, CERCLA makes any person who generates, transports, disposes of, or treats hazardous substances liable for the costs of response, in addition to the owners and operators of a facility from which a release occurs. CERCLA allows EPA to take action in a broader range of situations than is covered under any other environmental law.

CERCLA takes a two-pronged approach to addressing releases of hazardous substances: response and enforcement. Each of these in turn uses two approaches: for response, the two approaches are removal and remedial actions, and for enforcement, the two approaches EPA can use are making responsible parties take cleanup action, and recovering the costs of federal response actions from responsible parties. EPA can use one or any combination of these approaches to ensure that public health and welfare and the environment are adequately protected.

Taking Removal Actions

Removal actions are relatively short-term responses that EPA usually takes when prompt action is needed to prevent harm to public health or welfare or the environment. The following are examples of incidents that might justify conducting a removal action:

- Contamination of a community drinking water supply;
- Threat of fire and explosion, such as from drums leaking highly flammable liquid; and
- Potential for direct human contact with a hazardous substance, such as from an overturned truck spilling a chemical in a residential area.

As specified in the NCP, removal actions are taken when there is an "immediate and significant risk of harm" to public health or the environment at a site. Removals may also be taken in certain situations when an expedited, although not necessarily immediate response is needed. Removal actions are limited to six months and a total cost of $1 million, although EPA can grant exceptions when an immediate risk persists at a site.

EPA conducted a study in 1984 characterizing the types of threats posed by sites at which removal actions were taken.[16] Threats to human health were

present at 87 percent of the removal sites in the study. The environment was threatened by hazardous substances at 83 percent of sites where removal actions were taken. At three out of four removals, both human health and the environment were threatened. The most prevalent health threat was the potential for direct physical contact with hazardous substances, which existed at 79 percent of removal action sites. Another major human health threat was drinking water contamination, present at 21 percent of removal sites. Among environmental threats, soil contamination occurred most frequently, at 43 percent of removal sites.

Removals are taken most often at abandoned sites, such as dumps or inactive facilities. At active facilities, the owner or operator will often take the necessary response. Table 3-1 shows the substances found most often at removal actions: polychlorinated biphenyls (PCBs), pesticides, and heavy metals lead the list.

Although the types of measures taken during removal actions to control or eliminate threats to human health and the environment differ according to the conditions at a site, they range from installing security fencing around a site, so that access is limited, to excavating contaminated soil and transporting it off-site for disposal. Other actions that may be taken as part of a removal include, but are not limited to:

- Placing drums of hazardous substances in special packing containers to control leaking and to allow safe transport to a disposal area;
- Fighting a fire to stop the spread of noxious fumes;
- Installing a temporary barrier or digging ditches to control the migration of hazardous substances after a spill; and
- Providing bottled water or hooking up residents to a municipal water system when wells used for drinking water are contaminated.

Table 3-1. SUBSTANCES FOUND MOST OFTEN AT REMOVAL ACTIONS

Substance	Percent of Removal Actions
PCBs	23.3[a]
Pesticides	13.9
Heavy Metals	13.9
Unspecified Organics	9.3
Toluene	8.5
Cyanide	6.9
Benzene	5.4
Paints	5.4
Caustic Soda	4.7
Acids	4.7
Ethyl Benzene	3.9
Trichloroethylene	3.9
Xylene	3.9
Information Not Available	6.2

[a]The figures add to more than 100 percent because more than one type of substance may be found at a removal site.

Source: Office of Emergency and Remedial Response, U.S. Environmental Protection Agency.

Here are three examples of situations in which EPA has taken removal actions:

(1) Chlordane Contamination Site: In the fall of 1983, a "midnight dumper" illegally disposed of chlordane, an insecticide, in a residential well in Petersburg, West Virginia. The contamination threatened to spread to other wells used by nearby residents. EPA set up a system to pump and treat (with a carbon filtration unit) the contaminated well water. Sampling conducted in March 1984 showed that the amount of chlordane remaining in the well water was within acceptable levels. The pump and treatment unit were removed. The action was completed in just under six months at a cost of $40,000.

(2) Evans Trail Site: On May 25, 1984, a developer discovered approximately 300 deteriorating drums at a construction site in Calverton, Maryland. Samples taken indicated that the drums contained high concentrations of lead, chromium, and cyanide. Since two schools and an apartment development were located within 1/4 mile of the site, the drums posed a threat to students and nearby residents. At the state's request, the developer took steps to secure the site temporarily and thus to minimize the opportunity for the public to come into contact with the hazardous substances. EPA began a removal action on July 12, 1984. Drums onsite were removed and sent to a disposal facility in Ohio. Contaminated soil was also removed from the site, and a magnetometer survey was taken to determine whether there were any buried drums. No buried drums were located, and the site was graded and seeded. The removal was completed in August 1984 at a total cost of about $310,000.

(3) Western Processing Site: The site is a chemical recycling facility in Kent, Washington, that received and stored industrial wastes from 1961 to 1983. The site included approximately 4,000 to 6,000 drums, 70 bulk storage tanks, 10 surface impoundments, 5 PCB transformers, and various other structures containing hazardous substances. Over 80 hazardous substances were present at the site, including 48 known or suspected carcinogens. Some of the drums contained flammable hazardous substances and were releasing toxic fumes, creating a fire and explosion hazard. Other storage structures were in various stages of deterioration, leaking hazardous substances and contaminating soil, surface water, and ground water. There was a threat of direct human contact with hazardous substances. The removal action included the following:

- Removal and off-site disposal of drums and storage tank wastes;
- Construction of a barrier to prevent off-site migration of hazardous substances; and
- Construction of a containment pit onsite for certain substances.

Because of the high disposal costs, an exemption to the $1 million ceiling for removal actions was approved. The removal was completed at a total cost of approximately $1.4 million.

These examples illustrate EPA's flexible authority to take removal actions in a wide range of situations. As Table 3–2 shows, EPA has made extensive use of its removal authority: in 1984, 202 removal actions were completed, at a total

Table 3-2. **REMOVAL ACTIONS COMPLETED**

Sites	1984 Non-NPL[a] Sites	NPL Sites	1980 - 1983 Non-NPL Sites	Total	
EPA Conducted Removals	143	39	92[b]	104[b]	378
Coast Guard Conducted Removals[c]	20	0	21	1	42
Total	163	39	113	105	420

Total Removal Expenditures:
1980 through 1984 — $94.8 million

[a]"NPL" is EPA's National Priorities List, an inventory of sites that are candidates for remedial action.
[b]Figures include 22 removal actions funded under section 311 of the Clean Water Act when CERCLA funds were not yet available.
[c]The U.S. Coast Guard was given authority under the Clean Water Act to conduct removal actions when there is a threat to navigable waters or the coastline. This authority is still exercised when necessary.

Source: Removal Tracking System, Emergency Response Division, U.S. Environmental Protection Ageny.

cost of about $40 million. Since the inception of the Superfund program in December 1980 through 1984, 420 removal actions have been completed at a cost of approximately $95 million.

Steps in the Remedial Action Process

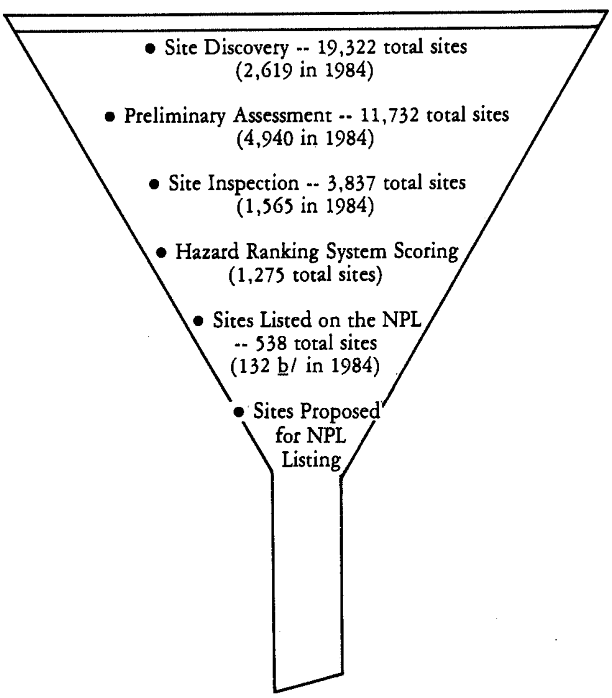
At many sites, a remedy cannot be achieved simply by removing drums or contaminated topsoil. Years of inadequate methods of disposing and handling hazardous substances may have led to extensive contamination of ground water and other media. These sites typically require a full-scale, carefully planned response, referred to as a remedial action. The remedial action process is a thorough attempt to remedy the most hazardous sites in the United States. The steps involved in the process include the following:

- Discovering sites that are candidates for remedial action;
- Narrowing the list of candidate sites to a list of priority sites;
- Extensively investigating contamination at each priority site to determine what cleanup measures are needed; and
- Constructing the remedy at each site.

Figure 3-2 shows the steps by which sites are selected for remedial action and the number of potential Superfund sites that have undergone each step from the beginning of the Superfund program through the end of 1984. As the number of sites being analyzed decreases after each step, EPA is able to focus its resources on those sites most in need of response. The steps in Figure 3-2 are described in this section, as is the remedial action process itself, which consists of remedial planning, design, and construction. Figures are provided showing the number of sites entering each of these phases during 1984.

FIGURE 3-2

EPA'S PRE-REMEDIAL ACTIVITIES[a/]



a/ Numbers reflect actual program data as of December 27, 1984.
b/ EPA proposed an additional 244 sites for inclusion on the NPL in October 1984.

SOURCE: Office of Emergency and Remedial Response, U. S. EPA.

Detecting Potential Sites

EPA may become aware of a potential hazardous substance site in any of a number of different ways. EPA regional offices frequently receive calls from state and local officials, particularly fire and police departments, and from concerned citizens notifying EPA of potential sites. In addition, some state environmental agencies have compiled inventories of potential sites within their borders and have made their information available to EPA. CERCLA itself led to the creation of a primary information source by requiring owners and operators of facilities handling hazardous substances and transporters bringing hazardous substances to these facilities to notify EPA of the existence of these facilities within six months after the passage of CERCLA. EPA may also become aware of potential sites from other sources, including evaluations undertaken to identify potential problems in particular industries.

To keep track of the universe of sites that may be candidates for remedial action, EPA developed a computer inventory system called the Emergency and Remedial Response Information System (ERRIS). The initial inventory of sites, totalling about 13,400, was compiled from the sources mentioned above (approximately 4,000 sites were added by the CERCLA section 103(c) notification requirement) and from two existing EPA data bases, which contributed approximately 5,500 sites. By the end of 1984, the number of sites on ERRIS was 19,300. Continuing efforts to identify potential sites are likely to result in an ERRIS list of over 25,000 by 1986. Figure 3–3 shows the growth in sites on the ERRIS inventory.

The ERRIS list includes many sites that do not require remedial action. In fact, the great majority of sites on ERRIS will not undergo remedial action. ERRIS is intended to serve as the comprehensive basis from which sites may become eligible for remedial action. It is EPA's list of potential sites.

Identifying the Most Serious Sites

Identifying from ERRIS those sites that pose the greatest threat and thus that should be given highest priority for remedial action involves three sequential steps:

- Conducting a preliminary assessment;
- Performing a site inspection; and
- Measuring the relative hazard at a site and ranking it on the National Priorities List (NPL).

A preliminary assessment (PA) is the first step in identifying the hazard at a site. Either EPA or a state will conduct a PA at every site on ERRIS. By the end of 1984, 60 percent of the over 19,000 sites on ERRIS had received PAs. The objectives of the PA are to determine (1) if there is an immediate danger to persons living or working near a site, and (2) whether a site should receive a site inspection. The data sources used to make these determinations are federal, state, and local government files, telephone conversations with state or local agencies that may have knowledge of a site, records of private and public wells, and sometimes a site visit. Environmental samples are not taken during a PA.

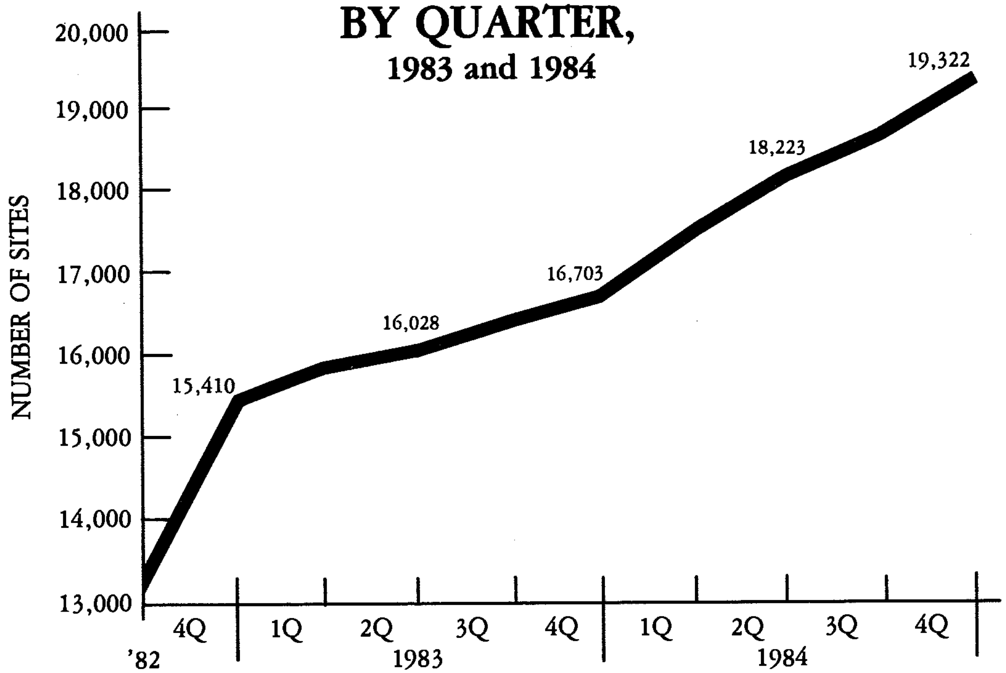
If, as a result of a PA, EPA or a state determines that there is an immediate threat to residents or employees at a site, EPA may conduct a removal action. Otherwise a site is classified into one of three categories:

- *No further action:* The site poses no threat to public health or the environment and thus requires no further investigation or response.
- *Pending:* The site requires additional information to determine whether a site inspection is necessary. Most sites in this category eventually undergo site inspection.
- *Inspection:* The site will undergo site inspection.

Of the 11,700 sites that had received preliminary assessments by the end of 1984, approximately one-third (3,800) had received a field site inspection (SI). The SI is a more in-depth investigation than a PA and provides data to determine whether a site should be included on EPA's list of priorities for remedial action. Site inspections require environmental sampling on or near the site to determine whether and what types of hazardous substances are present and to identify the extent to which the contamination has migrated. Significant resources are needed for preparing work plans, site safety plans, sampling, and

FIGURE 3-3

NUMBER OF SITES ON ERRIS BY QUARTER, 1983 and 1984



SOURCE: U. S. Environmental Protection Agency, Office of Emergency and Remedial Response (September 30, 1984).

conducting laboratory analysis of samples. An SI may take from one to six months to complete.

Based on an SI, EPA may determine that: an immediate removal action is needed; no further action is required; additional information is needed; or the site poses a significant but not imminent threat. If the last determination is made, EPA will use its Hazard Ranking System (HRS) to measure the relative risk posed by a site.

The ranking system was designed to meet the CERLA requirement that the President (whose authority was delegated to EPA) identify at least 400 sites warranting the highest priority for remedial action. This list is referred to as the National Priorities List (NPL). The HRS provides a numerical estimate representing the relative hazard posed by a site and takes into account the potential for human and environmental exposure to hazardous substances. A score is derived for each of three routes through which a release of hazardous substances can harm humans or the environment: ground water, surface water, and air. The three scores are combined, using a weighted average, to yield a hazard ranking score. Among the factors that will affect a site's score are proximity to a densely populated area or source of drinking water, quantity of hazardous substances present, and toxicity of hazardous substances. EPA regional staff provide quality assurance /quality control for each scoring to ensure that sites are scored consistently.

The possible range of HRS scores is from zero to 100, with 100 representing most hazardous. As a rule, the NPL is limited to those sites scoring 28.5 or higher. Exceptions have been made to meet a CERCLA requirement that sites designated by a state as the top priority site in the state be included on the NPL.

By the end of 1984, 538 sites had been listed on the NPL. CERCLA requires EPA to update the NPL annually. EPA is likely to add at least 250 additional sites in 1985.

The threats posed by NPL sites may be characterized in several ways. For example, the HRS records whether there has been an "observed release" of a hazardous substance from a site to ground water, surface water, or air. An observed release is recorded when samples are taken showing a higher than normal (called "background") concentration of a hazardous substance. Observed releases to ground water have been reported at 75 percent of the sites listed on the NPL by the end of 1984; observed releases to surface water were recorded at 56 percent of the NPL sites; and observed releases to air at 20 percent of the sites.

Analysis of the HRS data for NPL sites also provides estimates of populations within a specified distance from an NPL site. For example, approximately 6.4 million people are calculated as drawing drinking water from wells within three miles of where hazardous substances from NPL sites have been found.

NPL sites also pose a threat to sensitive environments. Based on data for sites on the NPL by the end of 1984, EPA estimates that freshwater wetlands are potentially at risk from 186 NPL sites, located at a median distance of 800 feet from these sites. Similarly, coastal wetlands are potentially threatened by 40 NPL sites at a median distance of one-quarter mile, and critical habitats may be threatened by 30 NPL sites at a median distance of 380 feet.

Narrowing the list of ERRIS sites to those that may present the greatest risks helps ensure that Superfund dollars are used where they are most needed, and thus where they will yield the greatest benefit. Remedial actions may only be taken at sites on the NPL.

Investigating the Most Serious Sites and Selecting a Remedy

Many questions must be answered before a remedial action can be taken.

- *What is the extent of the contamination?* What areas of the site are contaminated? What are the contaminants? How much contamination is there? If ground water is affected, how big is the contamination plume and where is its exact location?
- *How can a site be cleaned up?* What are the various alternatives? How would they be constructed? How much protection will they yield? How long will they take to complete? What will they cost?
- *What level of protection is adequate?* How clean is "clean"?

Answering the first two sets of questions requires a great deal of scientific and engineering expertise, backed by extensive sampling of the contaminated areas at sites. The third set of questions cannot be answered objectively — by engineers, scientists, or anyone else — but must be decided by policymakers, using the best information that can be obtained.

Ideally, a completed remedial action would provide total protection of public health and the environment. However, complete protection is not technologically feasible nor is it afforded in any other area of life. Some level of risk will always remain at a site. For example, it may be possible to reduce the amount of a hazardous substance in soil at a site to 1 part per billion, but the technology may not be available to reduce the concentration significantly below this level. Or if the technology is available, it may be so prohibitively expensive that it cannot be justified given the limited amount of money in the fund and the large number of sites needing response. Moreover, since wealthier is generally healthier, safety considerations alone mandate a spending cap. Finally, remedial actions are themselves risky and thus self-limiting. Because some level of risk will always remain, we must decide what amount of risk is acceptable, or what level of protection is adequate. The difficulty of this decision is compounded by the fact that scientific evidence on the health effects of different concentrations of hazardous substances is incomplete and sometimes conflicting.

There is no single answer to the question "how clean is clean." In attempting to answer this, EPA is considering adoption of a policy to pursue remedies that in general meet the standards of other federal environmental laws, such as RCRA and CWA. EPA has proposed this approach as part of revisions to the National Contingency Plan.

The first two sets of questions can be addressed more objectively, through a detailed and thorough process referred to as a remedial investigation/feasibility study (RI/FS). These studies are conducted at those sites identified through the NPL process as being priority candidates for remedial action. An RI/FS can be performed either by EPA, states, or responsible parties. Both EPA and most states generally use contractors to perform RI/FSs.

A remedial investigation involves extensive sampling to determine the nature and extent of contamination at a site and to characterize a site in terms of topography, geology, and hydrology. Before RI field work begins, a work plan is developed showing where samples will be taken and the number of samples that will be taken for each different medium (i.e., ground water, surface water, soil, air). On average, EPA or a state will take several hundred samples during an RI. RI sampling is conducted to evaluate contamination at the source and

the extent to which hazardous substances have migrated from the site. The samples are sent to approved laboratories for analysis to identify the hazardous substances present and their concentration. The accuracy of the sampling and laboratory analysis stages is verified through quality assurance/quality control (QA/QC) procedures. A specific QA/QC plan is prepared for each RI. In addition to sampling, an RI may include aerial photography and tests to determine the subsurface structure at a site, for example, the permeability of the soil.

EPA or a state will use the sampling results and information on site characteristics obtained during the RI to evaluate alternative types of remedial action. The evaluation of alternatives takes place during the feasibility study stage of the RI/FS. The alternatives are meant to encompass a wide range of options and will normally include: off-site treatment or disposal; meeting or exceeding federal public health or environmental standards; closely approaching but not meeting federal standards; and no action.

In addition to these options, EPA encourages consideration of recycling/reuse, waste minimization, destruction, and other innovative technologies to reduce the amount of hazardous substances. Removing contaminants to an off-site disposal area may in some cases only shift the problem, because there is a possibility the off-site disposal area will eventually require remedial action.

The alternatives identified undergo an initial screening based on (1) the cost of each alternative, (2) whether the alternative uses acceptable engineering practices, and (3) whether the alternative effectively protects public health and welfare and the environment. A more detailed evaluation is conducted of the alternatives that remain after the initial screening, during which each of the possible remedies is further refined and specified. The detailed evaluation will normally include an analysis of the extent to which each alternative meets or exceeds the relevant federal standards. The result of the detailed evaluation will be the recommendation of one particular remedial alternative.

As noted, EPA policy is to select a remedial action alternative that meets or exceeds the standards of other federal environmental and public health laws. Examples of federal standards that may apply at a site include the following:

- RCRA design standards for treatment, storage, and disposal facilities;
- PCB disposal regulations established under the Toxic Substances Control Act; and
- Maximum Contaminant Levels for drinking water sources, established under the Safe Drinking Water Act.

In certain circumstances, a remedy may be selected that approaches but does not meet federal standards. When an alternative is selected that does not meet standards, EPA or a state will conduct a risk assessment to determine the level of risk that will remain after the remedial action is complete. An example of a constraint that may prevent EPA from meeting standards is the "fund-balancing" provision in CERCLA, which requires that the need for response action at a site be balanced against the amount of funds available to respond to other sites.[17] If the cost of meeting standards is extremely high and affords relatively little additional protection, it may be difficult to justify because of the fund-balancing requirement.

The Outboard Marine Corporation site in Waukegan, Illinois, is a good example of how an answer to the question "how clean is clean" may be affected by the limited amount of money in the fund. There is extensive PCB contamination

in Waukegan Harbor and a few adjacent areas. The source of the contamination is a plant that used PCBs for 30 years for hydraulic fluids in die-casting machines. The cost-effective remedy at the site, one that would meet all federal standards, was determined to be removal of all PCB-contaminated materials to a landfill approved for PCB disposal under the Toxic Substances Control Act. The cost of this remedy was estimated to be $75 million. After taking into account fund-balancing considerations, however, EPA selected a less expensive remedial alternative. The alternative, which is estimated to cost $23 million, will involve dredging contaminated sediments from the harbor, removing the water from the sediments, and securing them in a "containment cell" on the site, with a cap placed over the cell. This remedy, at a much smaller cost, will closely approach the level of protection of public health and the environment provided by the $75 million remedy, with the remaining funds available for needed response at other Superfund sites.

Before a remedial alternative is selected, a three-week period is provided during which the public may comment on the feasibility study. A summary of the issues raised by the public and how they are addressed must be provided when the remedy is selected. (Public participation in Superfund is more fully discussed below.)

Because of the comprehensive analysis required, an entire RI/FS requires, on average, slightly more than one and one-half years to complete. The average cost of an RI/FS is about $800,000. Table 3–3 shows the number of RI/FSs underway through the end of 1984. EPA, states, or responsible parties had initiated 367 RI/FSs by the end of 1984.

States and federal agencies other than EPA can play significant roles during the RI/FS and other stages of the remedial action. As mentioned, states can conduct fund-financed RI/FSs and remedial actions and must share in the costs of all remedial actions regardless of whether an action is conducted by a state or by EPA. As an example of the role federal agencies other than EPA can play, the Department of Health and Human Services can perform health studies and health examinations connected with Superfund sites. As another example, the Department of Justice represents EPA in litigation to recover costs from responsible parties or to compel responsible parties to take cleanup action. Several other federal agencies have important roles in the remedial action process.

Table 3–3. **REMEDIAL INVESTIGATIONS AND FEASIBILITY STUDIES**

	1980–1983	1984	Total
CERCLA-Financed RI/FS Actions:			
— Number	169	147	316
— Expenditures ($ millions)	$81.9	$94.6	$176.5
Responsible Party RI/FS Actions	27	24	51

Source: Office of Emergency and Remedial Response, U. S. Environmental Protection Agency.

Here are three examples of remedial alternatives that have been selected based on an RI/FS:

(1) Drake Chemical Site: The site, located in Lock Haven, Pennsylvania, was operated for approximately 30 years as a chemical manufacturing facility. The owner filed for bankruptcy in 1981, after being charged several times with violating environmental and health and safety regulations. The major contaminant present is a herbicide, fenac, although a human carcinogen, beta-naphthylamine, has also been detected at the site. There is contamination of the buildings onsite, and of the ground water, surface water, and soil. Drake Chemical is ranked 334th out of 538 sites on the NPL.

The first phase of the remedial action will be to control the flow of a contaminant stream leaking from a lagoon onsite through a municipal park (now closed) to a creek south of the site. A pipe will be installed to collect the leachate stream, and contaminated sediments will be placed in a lined lagoon onsite. The second phase of the remedial action will address the remainder of the site, including ground water, sludge, and the buildings onsite.

(2) Highlands Acid Pit Site: During the 1950s, an unknown quantity of industrial waste was buried under sand at the six-acre site, which is located 16 miles east of Houston, Texas. In addition to soil contamination, investigations at the site detected the presence of relatively small amounts of metals and volatile organic chemicals in ground water. The site is listed 356th out of 538 sites on the NPL. The selected remedy includes excavating to a depth of eight feet to remove the buried waste and installing a ground water monitoring system. The remedy does not cover the slight contamination of ground water that has already occurred, because it does not present a perceptible health risk and including it in the remedy would result in a much higher cleanup cost.

(3) Tysons Dump Site: The site, located about 15 miles northwest of Philadelphia, Pennsylvania, is a former quarry that was used by several private companies to dispose of various industrial and municipal wastes. The site is located just over one-half mile from a municipal drinking water intake on the Schuylkill River, and is also adjacent to a residential area. The RI/FS, which was completed in September 1984, showed contamination of ground water, surface water, and soil at the site. The principal contaminant is 1,2,3-trichloropropane. The site is ranked 25th out of 538 sites on the NPL. The remedial work at Tysons Dump will be split into at least two phases. The first phase of the remedial action will include: excavating contaminated materials and transporting them to a RCRA-permitted landfill for disposal, improving a treatment system installed earlier at the site by EPA to remove hazardous substances from water, and continuing operation of the onsite treatment system for approximately five years, until ground water contamination is eliminated. The second phase will address the remainder of the off-site contamination.

Designing and Constructing the Remedy

After a remedy has been selected through the RI/FS process and has been approved by EPA's Assistant Administrator for the Office of Solid Waste and

Emergency Response, the remedy is undertaken.[18] This involves two steps: remedial design and remedial construction. The type of work performed during this stage is similar to work done for most large-scale construction projects.

Remedial design involves developing engineering blueprints with all technical specifications necessary for constructing the remedy. Remedial construction may include such activities as moving earth, excavating, installing supports and foundations, drilling, installing equipment, such as a leachate collection system or ground water treatment system, and regrading and revegetating the surface area at a site.

As is the case for an RI/FS, remedial design and construction can be undertaken either by EPA or a state. For EPA-led sites, the Army Corps of Engineers oversees all aspects of the remedial design and construction phase, including awarding contracts to engineering firms for design and construction, and providing onsite supervision to ensure that the remedial action is conducted according to design specifications. States provide oversight of contractors for state-led design and construction sites.

Regardless of whether a remedial action is state- or EPA-led, CERCLA requires that the state share the cost of the construction phase. If the state owned the site at the time of disposal, the required cost share is 50 percent; otherwise, the cost share is 10 percent. The typical cost for the remedial design phase at one site is $440,000. The estimate for remedial construction of one site is $7.2 million. Table 3–4 shows the number of sites at which remedial design and construction had been initiated by the end of 1984. These numbers are expected to increase sharply in 1985 and 1986, because of the recent large increase in the number of sites in the RI/FS stage.

After remedial construction is completed, a site enters an operation and maintenance (O&M) phase. Most remedies will require some form of active operation and maintenance. For example, O&M might include (1) checking that treatment systems are functioning properly and (2) replacing the mechanical parts of the system as needed; or O&M might require taking erosion control measures. The O&M period is also used to conduct monitoring to ensure that the remedy is operating as intended. CERCLA requires that states assume O&M costs for the expected life of a remedial action.

Superfund and the Public

The Superfund community relations program is an integral part of all response actions financed with fund monies. The purpose of the program is to keep the community informed about response actions at sites in their area and, to the extent possible, to involve communities in the decision-making process. Public involvement is important in the Superfund program because response actions can have a direct effect on the health of nearby residents and on their immediate environment. Response actions may even have measurable economic effects on property values near sites.

EPA requires that community relations activities be conducted both for removal and remedial actions. For removals anticipated to last longer than 45 days, a written, formal community relations plan must be developed. The community relations plan notes known community concerns about a site and outlines procedures for keeping residents informed about site activities. For

Table 3-4. **REMEDIAL DESIGN AND CONSTRUCTION ACTIVITY**

	1980-1983	1984	Total
CERCLA-Financed Remedial Design and Remedial Construction:			
— Remedial Design	17	16	33
— Expenditures ($ millions)	$ 6.4	$ 9.4	$ 15.8
— Remedial Construction	21	8	29
— Expenditures ($ millions)	$55.4	$54.5	$109.9
Responsible Party Remedial Design and Remedial Construction[a]	49	25	74

[a]The number of responsible party remedial design and remedial construction actions is greater than the number of responsible party RI/FS actions in Table 3-3 because EPA will sometimes conduct a CERCLA-financed RI/FS at a site and then negotiate with responsible parties to conduct the remedial design and remedial construction.

Source: U.S. Environmental Protection Agency, Office of Emergency and Remedial Response.

removals lasting less than 45 days, an EPA spokesperson is designated to provide information to residents near a site.

A community relations plan must also be prepared for all remedial actions conducted by EPA or a state. The plan must be prepared before field work begins during the RI/FS, must be based on discussions with local officials and citizens, and must be revised to reflect changing community concerns after a remedy is selected and before remedial design and construction begins. A final important aspect of the community relations program is the requirement that a three-week public comment period be provided on the draft feasibility study, before a final decision is made on a remedy. The comments received, along with EPA or state responses, are summarized and included with a document — referred to as the Record of Decision — that describes the reasons for selecting a particular remedy.

Enforcement Actions

The purpose of the Superfund enforcement program is to secure responsible party cleanup at sites wherever possible and to recover the costs of Superfund-financed removal or remedial actions. These goals are accomplished through the use of enforcement authority provided in CERCLA. CERCLA authorizes EPA, either by filing a suit in U.S. District Court or by issuing an administrative order, to compel responsible parties to take cleanup action. CERCLA makes site owners and operators and certain other parties liable for the costs of removal or remedial actions properly undertaken by EPA, states, or other parties. These CERCLA authorities are sometimes used in conjunction with enforcement authorities provided in RCRA.

Securing Private Party Cleanup

One of EPA's first steps at a hazardous substance site is to decide whether to use its enforcement authority to compel cleanup or to conduct a fund-financed removal or remedial action (and possibly recover costs later). The two most important considerations in making this decision are: (1) conditions at the site (i.e., whether response must be taken immediately), and (2) the likelihood of securing responsible party cleanup. It is desirable to secure responsible party cleanup when possible, primarily because it preserves fund money for use at other sites where responsible parties cannot be identified.

In order for EPA to coordinate its enforcement activities with its fund-financed response program, the Agency must (1) identify sites that are appropriate for enforcement actions, and (2) determine the point at which enforcement efforts should cease at a site and a fund-financed action should begin. To assist in performing these tasks, EPA uses a site classification system, based on such factors as the likelihood of success of the enforcement case, the need for prompt response at the site, and the ability of states to provide the cost-share required by CERCLA for a fund-financed response to begin.

If EPA determines that enforcement is appropriate at a site, the first enforcement activity undertaken is an attempt to identify potentially responsible parties. Regional EPA staff usually examine federal, state, and local government and private party records to identify past and present owners and operators of facilities at the site and generators and transporters of substances discovered at the site. States also conduct responsible party searches.

Once EPA has identified potentially responsible parties at a site, the Agency sends notice letters informing the parties of their potential liability and of opportunities for taking response actions. If responsible parties decide to negotiate at this stage, it may be possible to reach a settlement agreement that specifies the actions to be taken by the responsible parties. Negotiations are generally conducted only for sites requiring remedial action. A much shorter course of negotiation before certain removal actions may occur when there is time before site work must begin.

Before negotiations begin, EPA technical and legal enforcement staff prepare a draft enforcement document that details the specific technical issues (e.g., the suggested remedy at the site) and proposed terms of settlement. These issues then become the substance of the negotiations.

Negotiations in which EPA and the potentially responsible parties agree to the scope and terms of the remedy will generally result in a consent administrative order or a consent decree. A consent administrative order is a written agreement signed by EPA and potentially responsible parties specifying the actions to be taken by the parties. A party that fails without sufficient cause to comply with a consent administrative order may be sued by EPA under CERCLA section 107 for up to three times the costs of response made necessary by noncompliance.

A consent decree filed by DOJ is more formal than a consent administrative order. The Department must first file a complaint in federal district court, and the consent decree must be signed by a judge. The issuance of a consent decree does not necessarily mean that the relationship between EPA and the responsible parties during negotiations has been hostile. EPA encourages settlement by consent decree

as opposed to consent order because a consent decree is enforceable by the federal district court, although CERCLA does not authorize treble damage penalties for failure to comply with consent decrees. Consent decrees are especially encouraged when the number of responsible parties is large or the terms of settlement are complex.

If negotiations are unsuccessful and no settlement has been reached, EPA can (1) initiate a civil suit against responsible parties, (2) issue an administrative order requiring responsible parties to take certain cleanup steps, or (3) conduct a fund-financed response and attempt to recover costs. Although civil action can be more time-consuming than other approaches, EPA may decide to use it for several reasons:

- To compel responsible parties to stop conducting activities that endanger public health or welfare or the environment;
- To induce responsible parties to negotiate a settlement, without a long trial;
- To demonstrate EPA's willingness to make full use of its enforcement authority, and thus to provide incentives to other responsible parties to settle with EPA;
- To establish important legal precedents for other cases; and
- To use when other options have not been successful.

Before deciding whether to initiate a civil suit, EPA must determine whether response action can be delayed without increasing the threat to public health or welfare or the environment. When response must be taken promptly at a site, EPA will respond first and later sue responsible parties to recover fund expenditures.

DOJ, as attorney for the federal government, usually conducts the trial and related litigation, with EPA providing technical support during the litigation process. EPA will also participate in negotiations with responsible parties after a complaint has been filed by DOJ. Often, filing a complaint may prompt responsible parties to negotiate a settlement before or even during the trial itself. Settlement agreements reached after a complaint has been filed by DOJ are formalized in a consent decree signed by EPA, DOJ, the responsible parties, and a judge.

Alternatively, EPA may issue a unilateral administrative order requiring responsible parties to take response. These orders are very different from consent administrative orders because potentially responsible parties have not agreed to them in advance. A unilateral administrative order will usually contain:

- A description of the legal basis for the order, citing EPA's authority under CERCLA and the liability of the recipient under CERCLA;
- A statement of the steps that must be taken by the recipient to comply with the order;
- A mandatory timetable for the recipient to complete the required response; and
- A statement that the recipient may contact EPA to request a conference on the order.

Unilateral administrative orders are used not only when remedial actions are needed, but also when removal actions are appropriate. These orders are suited to removal situations because they can be issued quickly, can clearly specify the work required, and can be backed up by penalties and by the provision in CERCLA that makes responsible parties liable for three times the cost of

response action when they fail to comply with an administrative order. If the responsible parties agree with the order, EPA oversees compliance. If the responsible parties do not take the required response, EPA may initiate civil action or conduct a fund-financed response and try to recover costs.

EPA oversees cleanup actions taken by responsible parties to ensure that they are conducted as specified in an agreement, administrative order, or judicial order. Responsible party cleanups must comply with the response procedures set forth by EPA in the National Contingency Plan, ensuring that they provide at least the same level of protection to public health and the environment as do fund-financed removal and remedial actions.

Through 1984, the total value of settlements reached with responsible parties was $407 million. Over 40 percent of this total was accounted for by five large settlements since 1982, as noted below:

(1) Hooker Chemical (Hyde Park), New York: $30 million
(2) Olin Triana site, Alabama: $24 million;
(3) Velsicol Chemical site, Michigan: $24.5 million;
(4) Hooker Chemical (S-area) site, New York: $45 million;
(5) Petro Processors site, Louisiana: $50 million.

The value of unilateral administrative orders issued through 1984 was an additional $21 million. This amount includes only those orders with which responsible parties are in compliance.

Recovering Federal Response Funds

The goal of EPA's Superfund cost recovery efforts is to recover the maximum possible amount of money from responsible parties. As noted, responsible parties are liable for the costs of a removal or remedial action, whether incurred by the federal government, a state, or any other party.[19] In some cases, CERCLA makes responsible parties liable for three times the cost of a fund-financed response action. Responsible parties may also be held liable for damages for injury to or destruction of natural resources.

The cost recovery process involves the following steps:

- Documenting all costs incurred in a response action;
- Issuing a letter to liable parties summarizing the costs incurred and demanding reimbursement;
- Negotiating a settlement with responsible parties for cost recovery; or, where this is unsuccessful,
- Referring the case to the DOJ for litigation.

During the past two years, EPA has placed increasing emphasis on cost recovery actions. As EPA has stepped up the level of removal and remedial activity, the rate of fund expenditures has increased, and consequently the use of cost recovery as a means of helping to preserve the fund has taken on added importance. Through the end of 1984, cost recovery actions have yielded $11.8 million.

The Future of Superfund

A major EPA activity in 1984 was completing studies on the Agency's experience in implementing the Superfund program. The studies, which were required by CERCLA section 301, describe the progress that has occurred in addressing hazardous substance problems in the four years since the passage

of CERCLA and evaluate most of the key elements of the Superfund program, such as remedial and removal activities, enforcement activity, the state role in Superfund, and fund expenditures and revenues. The studies will help Congress and EPA shape the future of the program.

A central question addressed in one of the studies is, "what size fund will be needed in the future." This question is particularly important because the revenue-generating mechanisms for Superfund — the tax on chemicals and petroleum and the appropriations from general federal revenues — expire on September 30, 1985. Moreover, it is evident that there will be hundreds more sites needing response after the present Fund is depleted. EPA estimates future funding needs for the entire program at $11.7 billion. This estimate is based on an assumption that the NPL will eventually reach 1,800 sites. The estimate also assumes an average EPA cost (excluding states' required cost-share) for a remedial action of $8.1 million, and that responsible parties will clean up 50 percent of sites without the use of the fund.

Several bills have been introduced in Congress to provide funds to continue the Superfund program. All of the bills that have been introduced would significantly increase the size of the fund over the $1.6 billion established when CERCLA was passed. Most of the bills would also amend many of the current provisions in CERCLA generally to correct certain problem areas that were not anticipated when the law was passed, to clarify existing response and enforcement authorities, and to expand certain authorities.

EPA has identified four issues whose resolution will be integral to determining the future structure of the Superfund program:

Scope — What types of sites should be eligible for Superfund response and which should be excluded to preserve the fund and ensure that the worst problems are addressed?

Pace — What can EPA do to accelerate the pace of the remedial action program?

State Role — How can state involvement be increased to make for a more Superfund program?

How Clean Is Clean — To what level should sites be cleaned up to ensure protection of public health and the environment while also maintaining sufficient funds for responding to other sites?

The answers to these questions may be provided, at least in part, by the outcome of the Congressional debate over CERCLA reauthorization.

EPA addressed the scope issue in one of the studies under CERCLA section 301. Although EPA had identified over 19,000 potential hazardous waste sites by the end of 1984, the Agency believes that there are still many hazardous waste sites that have not been identified. In addition, Superfund is being increasingly called on to cover problem sites that received less emphasis in the first several years of the program. The categories of sites that could yield many more sites of potential concern include: certain facilities regulated under Subtitle C of RCRA; municipal landfills; industrial landfills; mining waste sites; and non-petroleum leaking underground storage tanks. The extent to which the scope of Superfund should encompass these and other categories of sites is an important outstanding question. In its reauthorization bill, the Administration proposed several amendments to ensure that Superfund responses are focused on those releases that represent the greatest threat to public health

and the environment, and to enhance EPA's ability to manage the program effectively.

The pace of the remedial action program is also an area of interest to EPA and Congress. EPA is considering ways to shorten the time required to complete a remedial action, which now averages about two to three years. For example, EPA is considering policy changes to speed up the RI/FS process, which currently takes an average of 18 months to complete. One change that has been instituted is to remove the requirement that states share in the cost of the RI/FS; obtaining this cost-share was often time-consuming. As the time required to complete a remedial action is reduced, protection of public health and the environment at a site can be more quickly achieved and remedial action at other sites can begin earlier. The administration has proposed several amendments to CERCLA designed to increase the pace of Superfund by making it easier to obtain settlements for responsible party cleanup.

EPA addressed the issue of the state role in Superfund in one of the studies under CERCLA Section 301. States, to date, have played an important role in the program, due to their authority to nominate sites for the NPL, their authority to conduct remedial actions, and the requirement that they share in the cost of every remedial action. In addition, the study showed that states conduct more short-term cleanups than does EPA. Although state funds for hazardous substance response tend to be largest in states with the greatest number of NPL sites, the level of state funds available in most states has been inadequate; in some states, the inadequacy of available funds has delayed remedial actions (because of the inability of the states to ensure that a cost-share will be provided). The administration is counting on the states to take a larger role in managing site cleanups and in shouldering a greater share of the cost, particularly given the financial surpluses many states are accumulating. A Superfund reauthorization bill proposed by the Reagan administration would make the state role an even more important element of the Superfund.

The "how clean is clean" issue has been subject to much debate and will not be easily resolved. As noted, EPA is considering a policy requiring that remedial actions meet the standards of other federal environmental and public health laws. This issue has never been addressed before on a scale as large as that required by Superfund. Although the issue is inherently difficult to answer, it is made more complicated at Superfund sites by the extent of contamination and the media affected (e.g., it may be easier to arrive at a consensus answer to "how clean is clean" for an oil spill on surface water than for extensive contamination of an aquifer far below the surface of a site), by the range of hazardous substances covered under Superfund, and by the differing health effects of these substances. Any resolution of this issue will substantially affect the future of Superfund. The administration has proposed an amendment that will ensure sites are cleaned up to protect human health and the environment, while preserving some flexibility to take site specific conditions into account.

Chemicals in Commerce: Coordinating the Regulation of New and Existing Chemicals

The Toxic Substances Control Act of 1976 (TSCA) provides the U.S. Environmental Protection Agency (EPA) with comprehensive authority to identify,

evaluate and, where appropriate, regulate risk associated with the life cycle of commercial chemical substances.[20] This authority encompasses both chemicals that are already in commerce and new chemicals before they are introduced. The legislation, however, deals with these two classes of substances somewhat differently. Consequently, it is not surprising that implementation of the new and existing chemicals programs by EPA's Office of Toxic Substances (OTS) has proceeded along somewhat separate tracks. With the accumulation of experience in implementing these two programs, it has become increasingly apparent that important policy interactions between the two programs need to be taken into account. This section explores the policy issue sometimes called "new source bias" as it applies to the regulation of chemicals in commerce under TSCA. It is important because regulatory procedures influence the pace of product innovation, and, thus, the likelihood that less risky chemical substitutes will be introduced which might reduce environmental risk.

Standard Setting Vs. Screening Approaches to Regulation

A general theme running through most U. S. environmental, health, and safety laws is a differing treatment of existing and new sources of risk. Peter Huber in an influential critique distinguished between "standard setting" and "screening" approaches to regulation.[21] Existing sources are generally subject to the standard setting regulatory regime, in which the burden is on the regulatory agency to identify sources of risk and to prove the need for control. Until such action is taken, there is no burden on those responsible for the sources of risk. By contrast, new sources are generally subject to a screening regime, whereby some form of regulatory approval must be obtained before the activity in question can be undertaken. For example, the Food and Drug Administration (FDA) distinguishes between new food additives and those "generally recognized as safe" (GRAS). The latter were existing additives in use in the late 1950s. New facilities, such as power plants or manufacturing plants, must receive a variety of regulatory approvals before they can be constructed or begin operation. Under the screening regime the burden is on those wishing to undertake the activity to show why the activity should be permitted. The economic burden involves both the cost of gathering and providing appropriate data as well as a delay in economic returns until regulatory approval is obtained. Furthermore, according to this view, the screening mode of regulation tends to encourage an extremely conservative attitude with respect to potential risk; regulatory policy tends to set much higher thresholds of safety for new sources than for existing sources.

Huber's explanation for the different treatment of new and existing sources is that those responsible for the legislation and its implementation believed that it would be cheaper to prevent risks than to address them after the sources of risk have become established. However, Huber argues that — in the long run — such a bias against new sources can result in both higher costs and increased risks. Higher costs accrue because economic progress is delayed; higher risks result because most new sources or products are substitutes for existing sources or products, and are inherently less risky. Therefore by delaying or even preventing the introduction of these substitutes, regulatory screening activities may make matters worse rather than better.

While Huber's basic argument is not without its critics (see, for example, Ashford),[22] he has raised important policy issues that can arise whenever society attempts to regulate risk prospectively. The issues, however, are not new ones. Indeed, these issues have been debated, in one form or another, during the development of TSCA and its subsequent implementation.

The Toxic Substances Control Act

Section 5 of TSCA provides the basic authorities concerning the review and regulation of new chemical substances. Anyone wishing to manufacture or import a new chemical substance must notify EPA at least 90 days before commencing such activities. EPA can extend this period for an additional 90 days; if the Agency has concerns about the substance, it can take a variety of regulatory actions. If the Agency believes that additional data are needed, section 5(e) of TSCA enables EPA to issue an order limiting or prohibiting the manufacture, processing, distribution, use, or disposal of the substance until the necessary data are provided by the submitter. When EPA has adequate data available, it can act to limit or prohibit manufacture, processing, distribution, use, or disposal under section 5(f) if it determines that an unreasonable risk exists.

Thus, the regulatory framework for new chemicals under TSCA does embody the screening concept. New chemicals cannot be produced for commercial purposes prior to government review, and there is a burden on the manufacturer to provide certain data to the Agency prior to production. The rationale for this approach was stated in the Conference Committee's report on the final legislation:

> The provisions of the section [section 5] reflect the conferees' recognition that the most desirable time to determine the health and environmental effects of a substance, and to take action to protect against any potential adverse effects, occurs before commercial production begins. Not only is human and environmental harm avoided or alleviated, but the cost of any regulatory action in terms of loss of jobs and capital investment is minimized.[12]

In contrast to section 5, the principal TSCA authorities involving testing and control of existing chemical substances follow the standard-setting model. Under section 4 EPA can require testing of chemicals for which concern exists. Whereas the comparable authority under section 5(e) involves the use of a relatively simple administrative order, section 4 requires full notice and comment rulemaking, which can significantly increase the time and agency resource requirements relative to section 5(e). During this period, as well as during the subsequent testing period, there is no restriction on the manufacture, processing, distribution, use, or disposal of the chemical. Section 6 of TSCA provides EPA with broad authority to regulate existing chemical substances. Again, however, except in cases of imminent hazard, a relatively long notice and comment rulemaking is required, during which manufacturing and other activities can continue. In summary, the major provisions of TSCA appear to make it easier for the EPA to regulate new chemicals than existing chemicals. This distinction raises the possibility that beneficial innovation could be impeded in implementing the Act.

However, in passing TSCA, Congress was far from insensitive to the potential for adverse impacts on innovation of new chemical substances. It recognized that major benefits would be derived from the continuation of vigorous R&D in new chemicals, and therefore directed that:

> . . . authority over chemical substances and mixtures should be exercised in such a manner as not to impede unduly or create unnecessary economic barriers to technological innovation while fulfilling the primary purpose of this Act to assure that such innovation and commerce in such chemical substances and mixtures do not present an unreasonable risk of injury to health or the environment.[24]

Compared with drug and pesticide regulation the screening burden under TSCA is much less costly and time-consuming. Unlike these other programs, TSCA is not a registration program; EPA does not have to approve a new chemical formally. If it fails to take a regulatory action within 90 days, then the chemical can be manufactured. Moreover, there are no up-front testing requirements; manufacturers only have to provide health and environmental effects data that they already have.

It is equally important that Congress did not mandate different standards of safety for regulatory decisions involving new and existing chemicals. The criteria governing action on existing chemicals and new chemicals when insufficient data are available are quite similar; they involve a determination either that the substance may present an unreasonable risk or that there may be substantial release or exposure. Likewise, when sufficient data are available EPA can control a chemical if it finds that the chemical presents or will present an unreasonable risk. This decision criterion applies both to new and existing chemicals.

EPA, of course, has considerable discretion in implementing these criteria. The concept of unreasonable risk, which is central to decision making under TSCA, is never formally defined in the legislation, although the legislative history does provide some guidance:

> . . . In general, a determination that a risk associated with a chemical substance or mixture is unreasonable involves balancing the probability that harm will occur and the magnitude and severity of that harm against the effect of proposed regulatory action on the availability to society of the benefits of the substance or mixture, taking into account the availability of substitutes for the substance or mixture which do not require regulation, and other adverse effects which such proposed action may have on society . . .
>
> Although the standard for defining the regulatory authority of the Administrator throughout the bill is "unreasonable risk", the implementation of the standard will of necessity vary depending on the specific regulatory authority which the Administrator seeks to exercise . . .
>
> The committee has limited the Administrator to taking action only against unreasonable risks because to do otherwise assumes that a risk free society is attainable, an assumption that the committee does not make.[25]

Taken together, the legislation and its history described above suggest that while Congress generally believed that prevention of health and environmental

risk was preferable to regulation of problems after they become significant, it understood that such prospective action must be balanced against the potential for unnecessary adverse impacts on innovation. Congress furthermore recognized that "zero-risk" was not necessarily an appropriate endpoint for either new or existing chemical decision making and provided EPA with broad latitude in making regulatory decisions in both program areas.

Implementation of the New Chemical Review

The review of new chemicals under TSCA began in 1979 following completion of the TSCA inventory of existing chemicals in commerce. Between then and the end of September 1984 EPA had reviewed 4201 Premanufacture Notices (PMNs). As of December 1984, the submission rate was running around 1200 chemicals per year. From this experience, it is possible to make a number of observations about the new chemicals that are being introduced:

1. *While the majority of new chemicals complete review without EPA action, a significant number do result in some form of regulatory or quasi-regulatory action.* Table 3–5 summarizes actions on PMNs submitted in FY84 (October 1, 1983 through September 30, 1984). Of 1192 chemicals, about 87 percent were dropped from the process. On the other hand, 3 percent were withdrawn because of concerns raised during the review, and another 4 percent were subject to formal regulatory action. About 6 percent are in suspended status, awaiting resolution of issues that arose during review.

2. *Most new chemicals represent modifications of well-known chemical structures.* Innovation in chemicals consists for the most part in making incremental modifications to existing chemical structures in order to enhance certain desirable functional characteristics or reduce undesirable characteristics. As a consequence many new chemicals are quite similar to those they would be replacing in the market.

3. *Relatively little test data are available in Premanufacture Notice submissions.* For example, one study found that 47 percent of PMNs submitted through June of 1982 had no toxicity test data.[26] Only 11 percent had subchronic test data, and 17 percent had mutagenicity data.

Table 3–5. Premanufacture Notice (PMN) Dispositions FY84 Submissions

Action	No. of PMNs
Drop*	884
Drop/followup**	152
Withdrawn	40
Regulatory action	44
Suspension	72
Total	1192

* Completed PMN review without regulatory action
** Completed PMN review without regulatory action, but referred

Source: U.S. Environmental Protection Agency, Office of Toxic Substances

The characteristics described above combine to present a policy dilemma for EPA. Since little test data are available, concerns about most new chemicals are identified based upon analogous existing chemicals for which some data are available. Since most new chemicals are similar to the substances they would replace, the latter are themselves suspect. These substances may, in fact, be the toxicity analogs upon which the concerns for the PMNs are based.

How consistent should EPA be in its actions on new and comparable existing chemicals? On the one hand, it could be argued that no action should be taken on the new chemical if it presents no greater risk than an unregulated existing chemical used for the same purpose. Yet many would be troubled by such an approach since, in their view, TSCA should be used to promote the development of safer substitutes for existing toxic chemicals. As a practical matter, the inherent difficulty of making relative risk comparisons in the absence of test data would mean that it would seldom be possible to judge a new chemical riskier than its existing counterpart. Consequently, such a policy could significantly increase the possibility of failing to identify and control a hazardous substance before it reaches the marketplace. EPA may, however, be able to use its authority under sections 4, 6, 7, and 9 to respond to risks posed by both new and existing chemicals when both types of chemicals pose the same types of risks. Although for new chemicals this may take longer to become effective than section 5 action, it would potentially address the entire risk, minimize effects on innovation, and treat new and existing chemicals on an equal basis.

Alternatively, one could decide that TSCA should act as a positive forcing agent in encouraging innovation of safer chemicals. Such a forcing scheme would regulate new substitutes for risky existing chemicals unless they are clearly less risky. Taken to an extreme through a conservative approach in assessing risk, and in face of the uncertainties cited above, such a policy could run the risk of encouraging the kinds of perverse results that Huber worried about: not only could there be high costs in terms of lost economic productivity, but the introduction of safer new substances might be delayed.

One of the reasons why such a result could occur is that PMN chemicals are extremely sensitive to up-front regulatory costs. Commercial viability of these new substances is uncertain; only about 60 percent of early PMN submissions have ever been commercialized. Even if successful, many new chemicals cannot sustain the up-front test costs that would be necessary to resolve uncertainties about the hazards. For example, a two-year bioassay to determine carcinogenicity could cost up to $1 million. While inexpensive short-term screening tests are available for certain effects, they may not be applicable in specific cases. Therefore, most potential 5(e) orders that would prohibit manufacture until testing is completed result in withdrawals; the 5(e)s that were put into effect for FY84 PMNs were consent orders that permitted manufacture under circumstances that would limit exposure. (However, there has been some voluntary testing on cases that were ultimately dropped or withdrawn.)

At least one critique of EPA[27] has asserted that by setting higher standards for the safety of new chemicals, EPA has introduced a "new chemical bias" into its decision making, to the detriment of both economic progress and relative risk reduction. Others, however, point to the small amount of test data being obtained on new chemicals as evidence that the new chemicals program has not been effective in accomplishing the intent of TSCA that ". . . adequate

data should be developed with respect to the effect of chemical substances and mixtures on health and the environment . . . ."[28]

The difficulties involved in attempting to reconcile regulatory policy relating to new and existing chemicals are readily illustrated through an example of a particular category of chemicals. The case of acrylates provides one such example.

The Case of Acrylates

Acrylates and the closely related methacrylates[29] are a family of commercially important chemicals that share a particular chemical structure featuring a highly reactive carbon double bond. The reactive properties of these chemicals make them useful in a variety of applications involving polymerization to form basic materials used in plastics, adhesives, inks, and coatings.[30] During polymerization, the individual monomer molecules link together to form larger polymer molecules characterized by repeating structural subunits. When polymerized or copolymerized with other materials, acrylates produce plastics and coatings with excellent clarity, toughness, and resistance to environmental and chemical attack. Examples of the widespread use of acrylate polymers include automotive coatings, house paints, plexiglass, and contact lenses. At the same time, this reactivity may be responsible for the chemicals' adverse health effects, which include skin and respiratory irritation and sensitization and potential carcinogenicity.

Acrylates are not new materials; they were introduced into commerce in the early 1930s and since then have found widespread use. In 1983 about 1.8 billion pounds of acrylates were produced. Over 80 percent of this total is accounted for by five major acrylates. In addition, there are about 100–130 other commercially available acrylates, most of which have annual production volumes of less than 1 million pounds.[31]

The vast majority of acrylate and methacrylate production is used in polymer manufacture. During the polymerization process the reactive groups are consumed as the individual monomers link together to form polymer chains. Because of their reduced reactivity and because their size limits biological availability, the final polymer products are generally of low toxicity concern. Occupational exposure to the acrylates during monomer and polymer manufacture is limited by the closed nature of the manufacturing processes and the acutely irritating properties of many of the materials. Occupational Safety and Health Administration (OSHA) standards exist for several of the major acrylate monomers based on their irritating properties.

Although currently accounting for only a small fraction of acrylate use, the most rapidly growing area of acrylate application is radiation-cured materials. In these applications formulations containing unreacted or partially reacted acrylates are applied to substrates as coatings, inks, or adhesives. The coated products are then passed under ultraviolet or electron beam radiation where final curing takes place. In such applications acrylates are used as prepolymers, which are the backbone materials of the final coating; crosslinking agents, which harden the cured material; and diluents, which lower the viscosity of the formulated product to facilitate handling and application. Where radiation-cured materials can be used they offer a number of advantages over conventional

coatings, inks, and adhesives. Since the radiation-cured coatings are largely solvent free, compliance with volatile organic air pollutant emission standards is facilitated. Moreover, a number of solvents are themselves known or suspected health hazards. In industrial operations radiation-curing can provide energy savings compared with conventional heat curing, increase the product throughput, and reduce space needs. Because of these advantages acrylate use for radiation-cured materials is projected to increase 10–15 percent annually.[32]

Because radiation-curable products contain unreacted acrylates, workers in product formulation facilities and at application sites could be exposed to acrylates in the process of handling, sampling, and applying these materials.

New Chemicals

Table 3–6 presents the number of acrylate and total PMNs submitted in FY80–84. There is a relatively high level of activity in this area; it is interesting to note that acrylate submissions roughly doubled between FY83 and FY84, a period in which total submissions declined slightly. In FY84 acrylates accounted for about 4 percent of all submissions. The majority of these acrylates are intended to be used in radiation-cured applications.[33]

Agency review of these materials has had to take into account the following considerations:

- Several existing acrylate materials have tested positive in animal-skin painting carcinogenicity studies. Although others may have tested negative, there is not enough knowledge to predict the toxic properties of a new acrylate material.
- Relatively little is known about worker exposure to acrylates during formulation or application of radiation-cured materials. Dermal and, in some cases, inhalation exposures are possible, although such exposures could be greatly reduced or eliminated by engineering controls and worker protection.
- While radiation-cured coatings as a class are replacing solvent-based coatings, an individual new acrylate is in most cases likely to substitute for an existing acrylate in a product formulation.
- Reliable short-term screening tests for acrylates have not yet been identified. In the absence of such tests, uncertainties about the carcinogenicity of an acrylate PMN could be resolved only by a full-scale animal study. Most new acrylates do not anticipate production volumes large enough to support the cost of this level of testing.

Table 3–6. Acrylate PMNs

Fiscal Year	Acrylate PMNs	Total PMNs
1980	3	281
1981	12	580
1982	14	839
1983	24	1301
1984	52	1192

Source: U.S. Environmental Protection Agency, Office of Toxic Substances

- Except for the OSHA standards, which are based on irritation and sensitization effects, exposure to existing acrylates in formulation and application is unregulated.

Faced with this information, EPA has chosen to take regulatory action on a number of new acrylates over the past two years. The strategy chosen has been, where possible, to negotiate consent orders with the PMN submitters. Such orders seek to permit manufacture while limiting potential exposure. Typically, the orders require the use of protective clothing and, where appropriate, respirators for workers engaged in manufacturing, processing, and use of the PMNs or products containing the PMN substances. One limitation of this approach is that under TSCA such orders can apply only to the original manufacturer and through the manufacturer to its immediate customers. EPA must subsequently issue a Significant New Use Rule (SNUR) extending the provisions of the order to all potential processors and users. Until the SNUR can be promulgated, the consent orders limit the submitters to direct sales to final users or to formulator-users. In certain markets this limitation can significantly restrict commercialization; as much as 90 percent of some firms' sales are through formulators or distributors.

Existing Chemicals

In the case of *existing chemicals* comparatively little attention has been given to acrylates under TSCA. No testing has been proposed under section 4, and regulatory consideration has been limited to preliminary reviews of a few monomers and some preliminary data gathering. Yet concerns for many of the existing acrylates are no different than for the regulated PMNs. Absence of formal regulatory action, of course, does not mean that EPA has determined that these materials do not present an unreasonable risk. Rather, it indicates that given previous priorities and commitments the Agency has not been able to access fully the need for regulatory action on these chemicals. For example, the Test Rules program under section 4 has given highest priority to chemicals nominated by the Interagency Testing Committee since these chemicals are under statutory and, in some cases, court-ordered deadlines. For whatever reason, however, action on acrylates under section 5, in the absence of comparable investigations on existing acrylates, has created at least an appearance of inconsistency between the new and existing chemicals programs. To respond to this problem during 1984 OTS recognized acrylates as one of several classes of chemicals where it has become necessary to develop integrated strategies toward new and existing chemicals to provide a balanced approach to their assessment and, if necessary, regulation.

Efforts to Coordinate New and Existing Chemical Activities

Acrylates provide a classic example of the problems that EPA faces in dealing with new and existing chemicals under TSCA. In the case of acrylates, the Agency is pursuing a strategy that would deal comprehensively with this category of chemicals, including both new and existing members. EPA is also looking at other mechanisms to eliminate inconsistencies between new and existing chemicals efforts. For example, OTS has initiated a policy to ensure that

existing chemicals undergo assessment and regulatory consideration when a similar new chemical is regulated under section 5, and that any determination in the existing chemicals process in turn be reflected in future new chemical reviews. In addition, OTS is also trying to reduce the economic burden of testing on new chemicals by using production volume triggers where appropriate for specific PMNs. Under this policy certain test data are required only when a specific aggregate production volume is reached, thereby allowing the manufacturer to determine the economic viability of the new product. In the interim production period measures are also required to limit exposure.

Conclusion

The great majority of exposures to potentially toxic chemicals can be attributed to existing commercial substances. Yet the great majority of chemical regulatory actions under TSCA have been on new chemicals. Given the nature of the statutes EPA has to implement, this situation is readily understandable. Yet, at the same time, experience in the PMN program has led to the recognition that many of the hazards identified are attributable to broad categories of similar substances to which the PMN materials represent incremental additions. Under such circumstances the overall effectiveness of EPA's regulatory activities might be improved by dealing with both existing and new substances in particular classes as part of an integrated regulatoty framework, considering the full opportunities for information gathering and risk reduction available under TSCA.

Chemicals in Commerce: Pesticides in the Environment—The Case of Ethylene Dibromide (EDB)

The federal government's authority to regulate the sale and use of pesticides and related chemical products is provided to the Environmental Protection Agency in the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) of 1972, as amended. Under this statute, EPA regulates commercially available chemicals that control insects, weeds, and diseases in agricultural production, disease vectors such as mosquitoes, and disinfectants and sterilants that are used in hospitals and homes, so that they do not cause "unreasonable adverse effects" on human health or the environment. In applying this standard, the law requires EPA to balance the health and environmental risks of pesticide use against its benefits to agriculture, public health, and the economy.

In this section the case of ethylene dibromide (EDB) illustrates how concepts of risk assessment and risk management apply to the control of a heretofore widely used pesticide. EDB became a household word in late 1983 and early 1984, as a variety of flours, cereals, and cake and muffin mixes were withdrawn from the shelves of supermarkets across the country after residues of EDB were discovered in certain food products. This section will also discuss recent program activities for pesticide regulation that have been expanded as a result of the agency's experience with EDB: more systematic testing for pesticides in ground water, improvements in the way tolerances are set for pesticide residues in food crops, and the communication of these risks to the public.

The Risk Assessment/Risk Management Paradigm

Risk Assessment Concepts

In a 1983 report the National Academy of Sciences distinguished between two aspects of the regulatory decision-making process: the essentially scientific enterprise of assessing the risk posed by a given situation (risk assessment) and the legislatively guided policy choices on how to manage that risk (risk management).[34] This paradigm, although most often used in conjunction with human health risks, is theoretically applicable to nonhuman environmental risks as well.

EPA's legislative mandates under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) and the Toxic Substances Control Act (TSCA) call for the Agency to investigate the extent and magnitude of risk associated with a given chemical or process. That risk is then balanced against a number of non-risk factors, for example, the benefits associated with a particular chemical and the availability and effectiveness of alternatives. The mandate under FIFRA speaks of controlling "unreasonable adverse effects" (Sec. 3(c)(5)(c)) ". . . taking into account the economic, social and environmental costs and benefits" (Sec. 2(bb)). The mandate under TSCA refers to controlling "unreasonable risk . . . to the extent necessary to protect adequately against such risk using the least burdensome requirements" (Sec. 6(a)). If the risks are judged to outweigh the benefits, then a decision is made which feeds back, reducing the risks (and possibly the benefits, as well) to the point that the benefits and risks are in balance.

For example, suppose a pesticide that provides the benefit of increased crop yields is found to cause cancer in laboratory animals. Such a chemical is assumed to pose a risk to humans who are exposed to the substance. That risk could theoretically be reduced by imposing control options that limit the application of the pesticide to a selected number of crops with low pesticide residue by specially trained individuals. In this way, the benefits to most crops, those with low residues, would be retained, while reducing or eliminating the risk to applicators or consumers of particular crops.

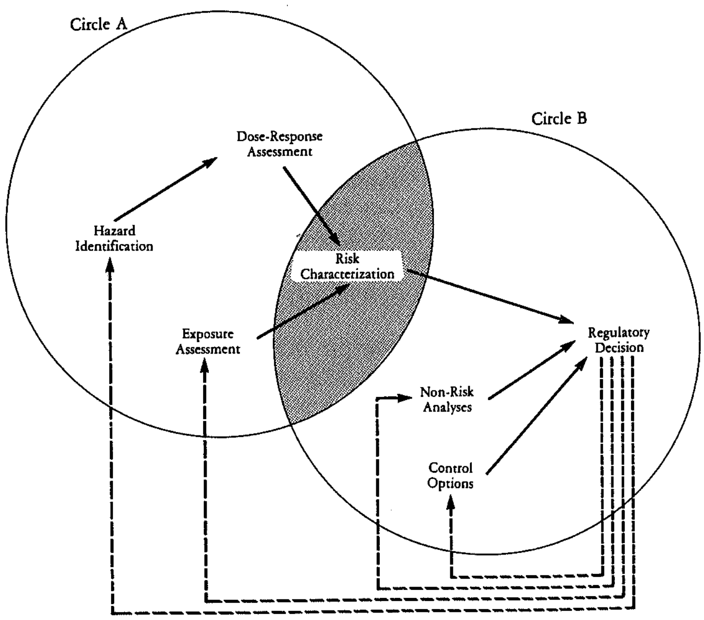
The elements of risk assessment and risk management, and their relationships are shown in Figure 3–4. Risk assessment encompasses the elements enclosed in the left-hand circle in the figure. First, in the *hazard identification*, the inherent toxicity of the chemical is assessed. For example, the Agency makes a qualitative determination, based upon the scientific data available, as to the likelihood that either acute or chronic exposure to a chemical can cause any number of toxicological effects (cancer, birth defects, fish kills), or environmental problems (ozone layer depletion, for example).

Second, data are analyzed quantitatively in the *dose-response assessment* to gain an appreciation as to how "potent" the chemical is in manifesting its toxic properties. Often this step involves extrapolating from carefully conducted studies in animals to anticipated responses in humans. In addition, results often need to be extrapolated from the high doses used in animal studies to the lower doses likely to be encountered in the general environment and specific situations, such as the workplace.

Third, the mere fact that a chemical is inherently toxic and "potent" is not sufficient to prove that a risk is present; there must also be exposure to that

FIGURE 3-4

RISK ASSESSMENT AND RISK MANAGEMENT



SOURCE: U. S. Environmental Protection Agency, Office of Pesticides and Toxic Substances.

chemical. Hence, the ***exposure assessment*** seeks to quantify the magnitude, frequency, and duration of exposure to the chemical (in different populations). For example, monitoring data or mathematical modelling of the transport and fate of a pollutant in the environment can give an indication of whether an individual is likely to be exposed to the substance in meaningful quantities. Similarly, in the case of risks to the natural environment, careful measurements or estimates are made to gauge the likely concentration of the chemical that will reach significant levels in vulnerable portions of the ecosystem.

Finally, results from the hazard, dose-response, and exposure evaluations are melded together in the ***risk characterization*** step, which includes both the qualitative judgment as to whether the chemical is a hazard and the quantitative judgment as to how great a risk is posed under the conditions of exposure discussed.

Application of Risk Assessment to Ethylene Dibromide (EDB)

A relatively simple molecule, CH_2Br_2, ethylene dibromide (EDB) has long been used as a soil, fruit, and grain fumigant to control nematodes (microscopic root-eaters) in the fields, fruit flies in citrus crops, and weevils in stored grain

and milling equipment.[35] In the late 1970s and early 1980s, however, experimental data showed that EDB was inherently toxic beyond previous estimations. At this *hazard identification* stage, data showed that EDB was a strong mutagen that produces multiple, malignant, invasive, short-latency tumors, in both sexes, in multiple species (not definitively shown in humans, however), at multiple doses, at multiple sites, in multiple experiments, by all routes of administration. In short, EDB was found to be a hazardous substance, that is, it is inherently toxic, as measured by traditional toxicological animal tests. Case reports in humans spoke to the chemical's toxic properties. However, the small numbers of people having any history of exposure to EDB ruled out the epidemiological approach to determine its human carcinogenic potential.

Data from the animal studies were used by EPA to generate a *dose response assessment*. In the process, the Agency utilized innovative techniques that incorporated the fact that EDB tumors appear in animals in a relatively short time following administration.

The *exposure assessment* phase for EDB has been aided by advances in analytical chemistry. For many years it was assumed that EDB, a volatile liquid, would leave no *measurable* trace in the soil, fruit, or grain to which it was applied and that it would not migrate in the environment. However, in the 1970s analytical chemistry capabilities advanced to the point that trace amounts of EDB were detected in fruit, grain, and grain products where previously there had been "zero" (i.e., non-detectable) amounts reported. As "zero" retreated to lower levels of non-detectability, positive EDB residues values were detected. That is, now we had finite exposures that might possibly signify significant risks.

The "case of the vanishing zero" testifies to the advances in analytical chemistry that allow us to answer the question "what's in this stuff?" at a finer level of detail. On the other hand, the vanishing zero also highlights the limitations of toxicologists to answer the companion question: "So what?"

EPA's initial concern arose over the detection of EDB in ground water. Following up on a 1982 report finding EDB in localized ground water in the south, EPA initiated a large effort, coordinated with the state of South Carolina and the U.S. Geological Survey, to validate the initial readings. Within two months, the data were confirmed.[36]

On a separate exposure front, in early 1984, EPA received information from a variety of sources that EDB residues were being reported in products on grocery store shelves. Once the first data became available, many other researchers, including those in other agencies and industrial groups, moved to expand the data base.[37] The additional data were generally consistent with the first reports. Thus, it became clear that human exposures to EDB through food products were greater than anticipated, that is, were greater than zero.

However, the situation was analyzed more closely by considering the effect of food processing and preparation on the levels of EDB that actually remained on the food when it was eaten. These residues in the "food-as-eaten" were considerably lower due to the removal of the outer part of the grain in processing and due to the heating and subsequent evolution of EDB vapors that takes place during baking.

These hazard, dose-response, and exposure evaluations were then combined in the risk characterization step. It was clear that hazardous EDB in ground water and EDB residues in products represented finite levels of risk where none

had previously been expected. The question then was: Is the risk acceptable or unacceptable?

Risk Management Concepts

Having established through the process of risk assessment that a level of risk exists, the Agency then turns to the risk management portion of the decision-making process. Here a variety of nonrisk factors must be considered, including the following:

- The benefits associated with the chemical's use;
- The availability, effectiveness, and toxicity of any substitutes;
- The availability and feasibility of any control measures designed to reduce exposure;
- The economic impact (for example, crop losses) of any proposed regulatory action.

Once this information is assembled, the decision-maker must weigh the risk and nonrisk factors and reach a judgment on whether the risks outweigh the benefits (that is, whether the risk is unacceptable). If it is determined that the risk is unacceptable, then an analysis is made of the various control options available, including but not limited to the following:

- Restricting the availability of the substance posing the unacceptable risk to certain individuals specially trained in its use;
- Restricting the use to geographic areas where ground water contamination is not likely;
- Eliminating certain uses entirely;
- Applying special warnings to the chemical;
- Banning the substance.

Based upon criteria in the applicable laws, a decision is made on what action would best reduce the risks to the point that they are outweighed by the nonrisk factors. As noted in Figure 3–4, this re-balancing is accomplished through the feedback that reduces exposure (and hence the risks) and possibly the benefits (e.g., restricting the use of the substance). In cases in which the substance is a mixture, the hazard may sometimes be reduced by requiring removal of offending impurities. A case in point is a recent EPA decision affecting pentachlorophenol (PCP).[38] This wood preservative chemical contains hexachlorodibenzo-p-dioxin (HxCDD) as an impurity. The decision calls for reduction in risk by reducing exposure through various restrictions, ***and*** reducing hazard (inherent toxicity), through a 15-fold reduction in the HxCDD content of PCP.

Application of Risk Management to EDB

For years the assumption had been made that the small quantities of soil fumigants used to control nematodes would never reach ground water. Nematocides, such as EDB, are generally volatile compounds so that even if they are incorporated into the soil during application, they were expected to slowly vaporize into the atmosphere. It was thought that any of the chemical that did not vaporize would be bound to soil particles and eventually decompose by physical, chemical, or biological processes.

As noted above, however, recent data suggested strongly that EDB did persist in the environment and did leach into ground water. The result of the risk characterization step indicated that lifetime exposure to EDB-contaminated ground water could pose a significant risk. Therefore, in the risk management step, EPA weighed this concern against a variety of nonrisk factors, including the following:

- Availability and cost of methods to clean up contaminated ground water;
- Availability, effectiveness, and costs of potential substitutes for EDB as a soil fumigant;
- Effectiveness of limiting, but not banning, the use of EDB as a soil fumigant.

After carefully considering the risks and nonrisk factors, the Agency concluded in late 1983 that nothing short of banning the soil injection use of the compound would adequately address the ground water contamination problem. In addition, EPA took the unusual action of issuing an "emergency suspension" to prevent immediately all future applications of EDB for soil fumigation. Cancellation, the alternative to suspension, involves a more elaborate review process and would delay the removal of EDB from the market.

Before this risk management decision to protect ground water could be fully implemented, the data concerning EDB in grain products and citrus fruit were reported. Subsequently, an assessment of the risks associated with consumer exposure was conducted for these uses. Good use was made of the data on residues on food-as-eaten and an assessment was made of the incremental risk associated with consuming (already treated) grain products that were already in the food distribution network.

In reaching the more complex risk management decision for EDB as a fumigant on fruit and grain, a number of factors were considered, including the following:

- Substitutes for citrus fumigation are not readily available although some are under development, for example, temperature treatment and gamma irradiation.
- The United States had assisted Latin American countries in developing citrus exports to the U.S. that utilized EDB fumigation.
- Substitute chemicals for fumigation of stored grain are available, although there are questions about the efficacy and toxicity of some of them. Among the alternatives were methyl bromide, which was under study in the Netherlands to determine its carcinogenic potential, and carbon tetrachloride, which has a long history of acute and chronic effects in other industrial uses.
- Public and political attention given to the issue appeared to surpass the level of the risk presented by the situation.
- Workplace practices could be altered to reduce the risks for workers handling fumigated fruit, but it would not totally eliminate their exposure.

This nonrisk information was balanced against the risk assessment for the various uses and a risk management decision rendered, elements of which included the following steps:

- Immediate suspension of certain uses of EDB as a soil fumigant;
- Immediate suspension of uses of EDB as a grain fumigant and as a "spot" fumigant in grain milling facilities;

- A phase-out over one growing season on the use of EDB as a fumigant for citrus;
- Establishment of recommended maximum acceptable EDB residue levels for raw grain, milled grain, and finished ready-to-eat products that were still in the food distribution network.

These responses constituted the risk management decision of the Agency regarding the pesticidal uses of EDB. As Figure 3–4 illustrates, these risk management actions feed back to earlier considerations in the risk assessment portion of the decision-making process. The inherent toxicity (its hazard) remains unchanged. Eliminating its use as an agricultural chemical will reduce the exposure and hence the risk. At the same time, the removal of EDB poses problems of finding adequate economical substitutes for its use as a fumigant. Projections are that the new regulations will cost the users up to $50 million and leave some questions about treatment for citrus unresolved. But given the magnitude of the possible risk and the intense public interest in the issue, these costs were not judged to be excessive.[35,39]

Additional Actions Associated with EDB

EPA's involvement with EDB has not ended with its emergency suspension of the chemical's registered uses as a pesticide. This section examines how other environmental and public health concerns raised by EDB have been addressed.

Since EDB was originally thought not to leave any residues on treated crops, the chemical was exempted from the requirement of a "pesticide tolerance." The tolerance is the maximum amount of the chemical allowed on a raw agricultural commodity when it leaves the farm on its way to market. Crops containing residues that exceed the tolerance level are subject to seizure by the Food and Drug Administration.

As an immediate step in the wake of the EDB revelations, the legal process was begun to remove EDB from the list of those substances exempted from tolerances. Since EDB would no longer be used on domestically grown crops, this concern was associated with EDB residues on imported fruits and grains. Recently, a tolerance level has been set, based upon known human consumption patterns (exposure information) and the known toxicity of EDB (hazard information).[40]

EDB is not alone among chemicals that are being removed from the list of those exempted from tolerances. In most cases, manufacturers of these pesticides will be required to conduct field trials to determine the residue levels that remain on treated crops. With these data and with information on consumption patterns, risk estimates will be made and decisions reached regarding the tolerance levels and the range of crops to which the chemicals may be applied.

In a more general sense, the methods used in setting tolerances for all pesticides are in the process of being vastly improved. The Tolerance Assessment System (TAS) being instituted by EPA incorporates a new method for estimating what foods are consumed by different sectors of the American public.[41] Traditionally, most estimates of pesticide ingestion via food have been limited to national averages of average daily food consumption, with the assumption that pesticides are always present at the upper legal limit, that is, the tolerance level. The TAS, which was pressed into service to assist in the EDB

assessment, provides dietary information on different age groups of people, different ethnic groups, and different regional groups. In addition, TAS incorporates more realistic "anticipated residue" (likely exposure levels on treated crops and food-as-eaten) information in place of the worst case assumption of "all that the law will allow."

The discovery of EDB in ground water added to the emerging awareness that pesticides pose potential threats to the nation's water supply. In recent years, EPA has addressed the larger question of ground water pollution by establishing an Office of Ground Water. In addition, a Pesticides in Ground Water Study has been initiated to explore on a national basis the presence of pesticides in this large, but limited, source of water.[42] Further, pesticide applications for use are receiving rigorous scrutiny to determine their individual potential for presenting ground water problems. As a consequence, the potential for problems is being minimized by restricting the use of certain chemicals where there is danger of ground water contamination.

It is interesting to note that the EDB problems — both ground water and fumigation — were initially identified by studies outside the pesticide registration process. The experience highlighted the need to identify and act upon important new studies in a timely manner. Therefore, systems have been established within the EPA pesticide programs to assure that new information of a potentially important nature to public health consideration is "flagged" early in the process.[43]

EPA is developing a national monitoring plan providing for the systematic collection of information on the extent of human and environmental exposure to and the effects of pesticides and related compounds (such as metabolites or contaminants of toxicological concern). This plan involves the collection of exposure-related information (such as chemical use pattern and usage information), the documentation of pesticide-induced illnesses and contamination episodes, the determination of chemical concentrations in humans and the environment, and the collection of information on user and industry compliance with provisions of FIFRA.

As an interesting footnote to the EDB furor of a year ago, it should be noted that 90 percent of the EDB used in this country goes into leaded gasoline, where it is used to scavenge the lead during the combustion process. Accidental releases of bulk gasoline into the environment through leaking undergound storage tanks could threaten local water supplies. Therefore, EPA is currently developing a plan to investigate and control such releases. In any event, another action — tightened controls on the amount of lead in gasoline — will reduce the amount of EDB in fuels and, hence, any EDB contribution to the leaking underground storage tank problem.

Finally, in the aftermath of the public attention directed at the EDB case a year ago, EPA commissioned a study to investigate its own handling of the problem.[44] Basically, the study indicated that — to quote former Administrator Ruckelshaus — "I believe we did the right thing; but I'm not so sure we did the thing right." Specifically, the study concludes that the public reaction was out of proportion to the significance of the risk involved. Attempts to explain the situation to the public were seen, in retrospect, to have been too complicated. What the public wanted to know was simply, "Is it OK to eat the bread?" It too often received answers couched in terms of probabilities and

lifetime risks. This experience suggests that, in the future, a concerted effort be made to offer straightforward statements that can be backed up by precise risk assessment statements and fully explained risk management decisions.

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Chapter 4

Special Report: Risk Assessment and Risk Management

In its 14th Environmental Quality Report (1983), the Council on Environmental Quality stressed the importance of consistency in the assessment of environmental and public health risks, and of flexibility in the adoption of regulatory approaches to the management of those risks. In particular, the Council recommended that all federal regulatory agencies strive to apply the procedures of risk assessment in a coordinated fashion. At that time, we also stated that the balancing of costs and benefits should be made an explicit part of risk management.

The Council continues to believe that this disciplined way of approaching environmental assessment and regulation is critical to the effectiveness and acceptability of the government's programs to reduce environmental risks. In an effort to advance appreciation for and understanding of this process by the Congress, the public, and other federal agencies, the Council includes a Special Report on Risk Assessment and Risk Management in this year's Environmental Quality Report. It sets forth the theoretical framework for conducting risk assessments and applying them to risk management decisions, as it has been conceived and practiced by the U.S. Environmental Protection Agency. The chapter includes four case studies to illustrate how these principles have been applied in actual regulatory decisions presented to the Administrator. The Council applauds the EPA for instituting and sustaining the effort that was begun in mid-1983 to systematically incorporate risk assessment and risk management principles in many aspects of agency policy and procedure. This management initiative is a model for other agencies, and provides the basis for refining these regulatory tools as federal agencies gain practical experience.

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The distinction between risk assessment and risk management was most succinctly explained by William Ruckelshaus, former Administrator of the U.S. Environmental Protection Agency (EPA), in a 1983 speech at the National Academy of Sciences (NAS):

> "Scientists assess a risk to find out what the problems are. The process of deciding what to do about the problems is risk management. The second procedure involves a much broader array of disciplines, and is aimed toward a decision about control. Risk management assumes we have assessed the health risks of a suspect chemical. We must then factor in its benefits, the costs of the various methods available for its control, and the statutory framework for decision."

The distinction between the two activities was thus an initial reason for the increased attention paid to them. This distinction was a major point in a 1983

NAS Report, *Risk Assessment in the Federal Government*, many recommendations of which are now reflected in EPA operations. One of the central principles of risk assessment and risk management is the separation of purely scientific judgments about the severity of a particular environmental problem (risk assessment) from decisions about what ought to be done about it (risk management). In the latter, considerations of economics, technology, and the law come into play; in the former, they should not. It is imperative that federal agencies avoid any suspicion, however misplaced, that statements about the severity of the risks associated with toxic substances are influenced by policy considerations, such as the costs connected with a potential control program.

This chapter describes EPA's recent efforts to apply the principles of risk assessment and risk management to the broad range of issues that confront EPA. It begins by defining those terms in the context of environmental policy and Agency operations and sets forth the reasons that a more systematic, consistent approach to the assessment and management of environmental risk is necessary.

The rest of the chapter discusses the ways in which risk assessment and risk management are actually applied in EPA decisions and in managing problems that fall under the purview of more than one federal agency. The application of risk assessment and management has led to several important EPA actions, including the decision to ban lead in gasoline. Risk assessment and management are now being applied to several of our most pressing and difficult environmental problems, including those of air toxics, sludge disposal, and hazardous waste incineration. In each of these areas, systematic appraisal of risks and risk management strategies is helping the Agency formulate an appropriate response.

As Agency management concentrated more attention on risk assessment and risk management, it became clear first that the distinction between them was not an easy one to make, and second, that these two activities make up most of EPA's mission. That is, most of what EPA does involves determining the harmful effects of pollutants on people and the environment ("risk assessment," broadly speaking) and deciding on the best way, under the statutes as written, of mitigating those effects—risk management.

The issue of Agency management was further complicated by the peculiar nature of EPA's mandate: implementation of nine environmental statutes, each dealing with a different aspect of environmental protection, and each carried out with a history of considerable independence. Given that, it appeared likely that although all environmental protection programs were doing the "same thing" (i.e., risk assessment and management), they were not all doing it in the same way.

The increased interest in risk reduction as a way of characterizing regulatory purpose also led to the idea that risk management might be useful as an integrating concept for the management of the Agency as a whole. Program integration has always been a problem for EPA leadership because of the fragmented mandate of the Agency. Nevertheless, such integration of environmental programs was one of the original reasons for establishing EPA in the first place. Failure to coordinate has often led to management difficulties, including the following:

- Unwarranted duplicative research on the same substance;
- Different programs producing different risk assessments for the same substance;

- Unwitting tranfer of pollutants from one environmental medium to another via pollution control technology; and
- Uncoordinated regulation of the same industry or the same substance by different programs.

Program integration problems tend to be exacerbated by the increased attention the Agency must pay to toxic substances, for several reasons. First, the number of potentially toxic materials is large. There are over 65,000 industrial chemicals listed as having been in commercial production since 1945. While many are not harmful, many others have not yet been characterized as to their toxicological potential, and a few thousand have some demonstrated toxic effect and are encountered in sufficient volume to be of concern. Since many of these chemicals are of concern to more than one program, scientists and managers in different regulatory departments find themselves concerned about the same substances more often than in the past.

Next, since hazardous substances are often not destroyed or permanently isolated by actions meant to control them, it is necessary both to keep track of their movements—preventing pollution control from degenerating into an expensive shell game—and to make decisions about the most acceptable endpoint for persistent pollutants. This is important because some toxics may have effects on health at exceedingly small concentrations, so that in some cases it may be impossible to establish a level at which they present no risk at all. Where banning such substances is infeasible, regulation must depend on some balancing approach.

These aspects of the toxics problem argue for a more integrated and readily comprehensible way to make regulatory decisions for the Agency as a whole. The regulatory mission has, in fact, changed substantially from what it was 10 years ago. Pollution control targets were more obvious then, and a very large proportion of the pollution tonnage was able to be controlled at a reasonable cost. But now, imposing further controls on large industrial sources may cost a great deal and have relatively little measurable effect. Indeed, some studies suggest that quite different categories of sources, such as small-scale dispersed industry or even sewage treatment plants, may be considerably more important sources of toxic substances than the remaining pollutant emissions from major industry.

A much greater degree of cooperation among EPA's regulatory programs is necessary for dealing effectively with today's environmental problems. Broadly speaking, the purpose of the Agency and the reason for its existence is to reduce environmental risk. To do so effectively, it is increasingly called upon to determine which of a number of possible controls, under different statutes, will reduce that risk the most. One of the principal objectives of risk assessment and risk management is to provide a means of making those determinations, under conditions of enormous scientific uncertainty.

As noted earlier, neither risk assessment nor risk management is new at EPA. Nothing now planned is going to make these processes easier or less complex. They are inherently difficult things to do. *What EPA hopes to accomplish by the current emphasis is to foster consistency by using the best science and reasoned value judgments, across actions and across programs in both risk assessment and risk management, and to make the judgments and decisions that go into regulatory decisions more explicit.*

The requirement of EPA's risk management approach is to demonstrate, to the extent possible, what each regulation *does*, in terms of reducing risk. Although this requirement may appear simple, it is difficult in practice. In fact, in the language of some of the most important environmental statutes, there is no such requirement to show precisely what effect controls on particular sources had on particular environmental values. Instead, the Agency was required to put into place controls based on specific removal technologies on the assumption that, taken as a whole, the environment would improve and the benefits would outweigh any costs. Risk management does not, of course, imply any departure from what these laws oblige the Agency to do; whatever is done beyond risk assessment that leads to decision making *is* risk management.

This initiative enables the senior management of EPA to play a more integrative role than has been possible before and make it easier to explain to the public why it has acted in particular cases. More specifically, the following advantages stem from this approach:

- *Risk management helps set priorities.*

As already noted, there are now thousands of chemicals in commerce and an unknown number of contaminants and degradation products. EPA does not have the resources to test each chemical exhaustively. We must also take some account of the subtle and unknown ways these chemicals mix in the environment—possibly in combination producing hazards that they may not exhibit separately.

Some of EPA's priorities will always be set from outside, either by Congress or through the press of emergencies, but it would be foolish to suppose that the great underside of the iceberg will somehow take care of itself. EPA cannot escape the need for an analytic approach to setting its own agenda. Screening by estimates of potential risk (i.e., hazard plus exposure) is an attractive basis for such an approach.

- *Risk management provides a context for balanced analysis and decision-making.*

The effects of some chemicals are legitimately frightening: they can and do cause cancer and other diseases. The problem is that we are exposed to a complex, highly dilute mixture of chemicals, which are taken in through air, water, and food. When disease strikes, cause and effect are seldom clearly linked. Often the regulatory situation, in which any action may involve substantial health or economic impacts and in which the scientific basis is highly uncertain, allows extreme points of view to develop. This polarizes debate, and sometimes brings public policy to an impasse. EPA may lose public support for its decisions, in part because it lacks a well-understood means of communicating the balances involved in any regulatory decision. Although such issues will continue to arouse strong emotions, EPA can contribute to rational discussion by exposing the scientific basis for the risk, including the confidence EPA has in the estimate; placing the risk reduction expected from the regulation in the context of other risks and other opportunities for risk reduction; and explaining the values on which the balancing judgments have been made.

- *Risk management produces more efficient and consistent risk reduction policies.*

EPA's patchwork of authorities for controlling pollution needs to be woven together more coherently, beginning at the analytical level and continuing

though to the regulatory decision. Some important statutorily defined differences in the ways the laws manage risk will always remain, but a risk management approach uses EPA's considerable administrative flexibility to make more effective and efficient use of Agency and social resources to reduce risk and to make the Agency's actions more consistent.

Enhancing *efficiency* means examining all available regulatory opportunities across all programs and selecting those that buy the most risk reduction for any given level of resources. Note here that risk reduction is not necessarily the same thing as pollution removal from a particular medium. For example, a control might simply take a substance out of the air and empty it into a sewer, from which it may eventually become a water pollutant or a sludge contaminant or reevaporate again as an air pollutant—yielding little or no net reduction in risk. Ideally, an Agency-wide risk management approach would flag such transfers and similar inefficiencies, and help avoid them.

Consistency is an essential part of rational management. At the least, EPA intends to use consistent methods of assessing risk for the same substances across programs. Initiatives discussed later in this chapter are aimed at establishing the same consistency across all federal agencies that deal with a particular problem. Although variations in statutory mandates may require different agencies or offices to respond differently to similar risks, a consistent method for understanding the connection between statutory goals and agency actions is still necessary. Further, unless risks and their control are treated consistently, we will almost certainly fail to recognize opportunities to reduce risks in one arena that may contribute more to public health and the environment than further expenditures in another. Consistent policy making based on well-articulated principles is perhaps the most important element in creating a strong base of public understanding of EPA actions.

Although these risk assessment and risk management principles can help environmental agencies set priorities, manage more efficiently, and make more consistent and rational decisions, they do not yield neat numerical solutions for all regulatory problems. However, they do provide a structured framework for making informed judgments, even when only qualitative information is available. The approach works best when the risks under consideration are relatively well-understood, and where a consistent metric (e.g., human health risks) is available for comparing problems and control strategies. It works less well in cases where the causal connections between an agency action and environmental improvements are difficult to establish, and where agencies must compare problems that affect different populations.

This problem is particularly apparent in dealing with ecological effects. It is often extremely difficult to relate changes in pollution loadings with changes in the health of an ecosystem because of limitations in the underlying scientific knowledge. It has been practically impossible to establish noncontroversial measures for the health of an ecosystem or for the value of that healthy environment. But the difficulty of analyzing such problems does not mean that they are unimportant, and policies whose benefits elude quantification should not suffer at the expense of policies with more readily definable payoffs. By presenting the best information available on all risk reduction benefits and costs of a policy under consideration—quantitatively or, if necessary, qualitatively—risk assessment and management approaches help the policy maker assess the

outcome of his or her decision. Risk assessment and risk management thus need to be applied with reasoned, enlightened judgment: it is necessary to pay attention to the numbers, but it is as inappropriate to adhere blindly to the numbers as it is to ignore them entirely.

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The remainder of this chapter is divided into three sections. The first section describes the structure of the risk in the EPA regulatory context, particularly as it applies to the assessment of human health risks. It briefly describes the wide range of activities that the Agency uses to describe and quantify the effects of pollutants on human health and the environment. Assessments of risk are inherently imprecise, because knowledge is incomplete, and because the results of the process depend heavily on the procedures and assumptions used. The line separating "science" from "policy" is not a sharp one, in that judgment must be used where firm data are absent. For example, one has a continuum from "fact" (scientific data) to "consensus" (generally agreed upon items) to "assumptions" (e.g., a man weighs 70 kilograms) to "science policy" (e.g., should we pool benign and malignant tumors) to "policy" (entire regulatory package including cost-benefit/cost effectiveness analysis). To avoid the necessity for ad hoc judgments in individual cases (and thus raise the suspicion of political influence on specific risk findings), it is essential to develop generic inference guidelines for different aspects of risk assessment.

The second section discusses current and new approaches for applying risk management concepts to the regulatory process. EPA's programs have differing mandates with respect to public health protection, and these bear significantly on the way the Agency deals with pollution control. The variety and uncertainty of risks from toxic substances makes exercising these mandates complicated and difficult. Risk management involves statements about values and about the way that EPA interprets its statutory mandates. The public has a right to know what values the Agency is applying.

The third section of this chapter consists of several case studies of the way risk assessment and management have contributed to recent or ongoing EPA activities, including the decision to ban lead in gasoline, regulatory decisions and new approaches regarding toxic air pollution, national approaches to the disposal of sludge, and decisions on the incineration of hazardous wastes.

Risk Assessment: An Overview of the Process

EPA regulatory decisions address a wide range of possible pollutant effects. Human health concerns include genetic damage and neurological effects as well as cancer, and EPA also considers such adverse environmental impacts as crop damage, visibility impairment, and ecosystem disruption. At present, however, EPA has progressed further in developing procedural guidelines for human health risk assessment than for environmental effects. Also, quantitative analytic techniques are most refined for cancer assessment. The focus of this section is mainly on innovations in this narrower area of human health risk assessment.

Although health risk assessments are conducted by scientists, they are not,

classically speaking, "science." For regulatory purposes, risk assessments represent a tool that can be used to analyze scientific evidence in order to evaluate the relationship between exposure to toxic substances and the potential occurrence of disease. The risk assessment process involves data that vary enormously in quality and quantity. No one should be misled into believing that results using present techniques have the status of scientific findings. Despite its uncertainties, however, risk assessment is the *only* tool available for making discriminations among environmental health problems. The central question is the extent to which risk assessment judgments can be made more consistent and more reflective of the state of scientific understanding.

There is no set formula for conducting a risk assessment. Because it is an analytical tool, it must be tailored to the needs of the program in which it is used. Given the different mandates within the Agency, it is not surprising that there are a variety of reasons for performing risk assessments and an equal variety of methods used to conduct them. Some examples follow to demonstrate the diverse nature of these assessments.

Risk assessments on carcinogens are assessments of risk in the strictest sense, for example, an estimation of the probability of developing cancer as a direct result of chemical exposure. No level of exposure is assumed to be without risk: carcinogens are assumed not to have thresholds. The data underlying such assessments typically involve animal doses much higher than the exposure levels expected for the human population. Therefore, the risk assessments must use probabilistic models to draw dose-response curves to extrapolate from the higher, experimental dose levels down to the zero exposure point. The product of this kind of study is a statement of the probability (risk) that additional cases will be associated with some given exposure level. This probability is usually expressed as a unit dose value, or risk per unit of exposure, such as risk per part per million (ppm) of a substance in the air or in drinking water. This unit risk can then be multiplied by exposure levels to calculate individual risk and by the number of people exposed to generate estimates of cancer incidence.

This approach to risk assessment can be used for studying any health effect where thresholds cannot be determined, provided that adequate data exist to construct a dose-response curve. Note that efforts are underway (such as in EPA's air program) to develop probabilistic risk estimates for noncarcinogens.

In other types of risk assessments, where a threshold effect has been associated with a toxic substance, the aim of the analysis may be to determine the "safe" or no-effect level of exposure. This is a more straightforward exercise. Information derived from animal experiments or from human data, if available, is used to establish a "no-observable effect level" (NOEL) or "lowest observed effect level" (LOEL) for the substance in question. Such levels are then divided by estimated uncertainty factors (which vary depending on the nature of the supporting data) to produce an acceptable exposure level. These resulting levels may be expressed as maximum contaminant levels, acceptable daily intakes, and so on. Probabilistic risk estimates are usually not generated by such analysis and persons exposed to levels of pollutants below these acceptable exposure levels are asssumed to be safe. An example of this type of analysis is the generation of acceptable daily intakes (ADIs) for a variety of chemicals that may pose risks to human health.

Risk assessments can also be used as a screening device for setting priorities

or as a method for quickly ranking the relative toxicities of large numbers of chemicals. While this type of approach is usually less detailed, it is important because formal risk assessment is slow and expensive, and more immediate decisions are often needed on the handling of many chemical species that have not been fully assessed. Two examples of this type of assessment are the Superfund hazard ranking system and the health scoring methodology used by the Integrated Environmental Management Division in the Office of Policy, Planning and Evaluation. Also, the Office of Toxic Substances uses abbreviated risk assessment methods that rely heavily on structure-activity relationships to screen new chemicals that lack adequate toxicological information. Where specific geographical areas have been contaminated with toxics, the Agency must respond with an assessment of the immediate danger to people in the area and, in some cases, with estimates of the risks associated with various cleanup options. These assessments do not necessarily differ in kind from those mentioned above. However, almost all of this work takes place at the regional level, especially with regard to Superfund sites.

The Structure of the Risk Assessment Process

In the simplest sense, population risks from toxic pollutants are a function of two measurable factors: hazard and exposure. To cause a risk, a chemical must both be toxic (it must present an intrinsic hazard) and be present in the human environment at some significant level (it must provide opportunity for human exposure). Risk assessment interprets the evidence on these two points, judges whether an adverse effect will occur, and (if appropriate) makes the necessary calculations to estimate the extent of total effects.

In a regulatory setting, risk assessment has one or more of the following four steps. An assessment usually begins with hazard identification or exposure. If either is negative, one does not proceed.

1. Hazard Identification

This exercise involves weighing the available evidence and deciding whether a substance exhibits a particular adverse health effect. Most attention has been focused on cancer, but EPA may also consider regulating on the basis of other effects, such as damage to fetuses (teratological effects), inherited genetic effects, and damage to specific organs, such as the liver or kidneys.

2. Dose-Response Assessments

Once it is determined that a chemical is likely to cause a particular human effect, then its potency is estimated: how strongly it elicits that response at various levels of exposure (dose). Chemical potency varies widely; for instance, both saccharin and dioxin cause cancer in animals, but it takes literally millions of times more saccharin than dioxin to produce equivalent effects in the laboratory.

3. Exposure Assessment

An estimate of the likely degree of human exposure to a chemical of concern

is then made. The best method is direct measurement or monitoring of ambient conditions, but this is often prohibitively expensive. In practice, estimates of emissions, limited monitoring information, with mathematical models that estimate resulting concentrations, are usually used.

The degree of exposure of concern may vary from pollutant to pollutant. For many effects, EPA may be primarily interested in lifetime exposures over the whole population; for others, EPA may be concerned about maximum levels of exposure to people near the emission source, or peak levels of short-term exposure. Unusually sensitive portions of the population are also of concern.

4. Risk Characterization

Finally, we calculate the risk associated with the particular exposures in the situation being considered for regulation. While the final calculations themselves are straightforward (exposure times potency or unit risk), the manner in which the information is represented is important. The final assessment should display all relevant information pertaining to the decision at hand, including such factors as the nature and weight of evidence for each step of the process, the estimated uncertainty of the component parts, the distribution of risk across various sectors of the population, the assumptions contained within the estimates, and so forth. For example, risks of cancer from benzene are different for petroleum refinery workers, service station employees, motorists who use self-service gas stations, and the remainder of the population.

Uncertainty in Risk Assessment

Given the usual limitations in the nature and extent of information available in this process, the assessment cannot determine exactly how many people will be affected by a particular pollutant or how severely. Not enough is known about how pollutants contribute to certain diseases or about the nature of human exposure to make definitive findings possible.

Definable relationships occasionally exist between certain diseases and certain substances, as they exist, in a more verifiable way, between diseases and bacteria. The task of risk assessment is to make the most useful possible statements about these relationships, to reduce uncertainty as much as possible, and to make explicit whatever uncertainty remains.

1. Weight of Evidence Problems in Hazard Identification

Most risk assessments depend on animal tests. These tests allow rigorous control over many factors that contribute to uncertainty, but fundamental problems remain. For instance, animal biological systems are different from human ones. Some species appear more sensitive to certain substances than humans, while others are less so. This leads to uncertainties in interpreting results. For instance, a certain chemical may be a strong carcinogen in various test animals, but it induces a type of tumor that humans do not get. Alternatively, the chemical may be a strong carcinogen in only one animal species. Should the chemical be considered a likely human carcinogen?

2. Uncertainties in Dose-Response Assessment

Despite existing policy and science practice, it is not entirely clear that *safe levels* or *thresholds* truly exist for any toxic chemical. While immediate effects such as respiratory distress may not occur after short exposures to low doses, subtle damage to health may occur, after long-term, low-level exposure and could have enough significance to the population as a whole to be worth controlling.

Also, as mentioned above, scientists must extrapolate dose-response relationships from animals to humans. Dosages must be corrected for human-animal differences in weight or metabolism. Effects at low doses must be inferred from high-dose results in laboratory or epidemiology studies. For cancer, results are typically couched in terms of the maximum amount of excess disease that a chemical is likely to produce. This is a complex process, with uncertainties attached to every judgment and inference made. Because of its complexity and its heavy reliance on assumptions, dose-response estimation for carcinogens is a particularly controversial aspect of risk assessment.

3. Uncertainty in Exposure Assessment

Thus far, exposure assessment has attracted less controversy than the other stages of risk assessment, but it also involves uncertainty. Exposure assessment is based on human monitoring, ambient monitoring, modelling, or some combination of these. Human data are typically quite limited because of uncertainties in science and monitoring data and because of the expense and time required to gather long-term (annual or longer) concentration information. Modelling is therefore often used as a substitute. In this technique, data on pollutant releases, release characteristics, meteorology, hydrology, geography, and other information are gathered, and computer models are used to calculate the distribution of pollutants into the communities around the sources. The exposed population is then estimated through census data, water outlet data, etc. The uncertainties in all of these estimates are enormous and may significantly influence or even determine the results of the assessment.

Importance of Science Guidelines

To make progress in the face of such uncertainties, EPA is developing what the NAS report calls "science policies" in the shape of formal "inference guidelines." Despite scientific consensus endorsing such an approach, there is still debate about the degree to which standard procedures can or should be defined and about the terminology involved in the process. The NAS report recommends, and EPA concurs, that greater consistency in the risk assessment process is not only possible but also essential.

Following the NAS report, EPA approached the various judgments involved in toxic risk assessments hierarchically, proceeding from broad statements of principle to more detailed directions for interpreting data and making quantitative inferences regarding risk.

1. Principles

Assessments have historically been based on a number of underlying principles, such as the judgment that animal bioassays are indicative of probable

human response, or that no threshold of response to carcinogens can be confidently defined. A statement of principles may include simple observations of fact, statements of broad-based scientific consensus, or judgments about "science policy." While debate continues in some areas, there is wide scientific agreement on most of the principles driving the assessment of cancer risk.

The most comprehensive reference on the subject is the recent document by the Office of Science and Technology Policy, entitled *Chemical Carcinogens; Review of the Science and Its Associated Principles*. This document, published in the *Federal Register* (May 22, 1984) provides a thorough and well-referenced review of current knowledge about the physical, chemical, and biological events underlying the process of tumor development. As yet, no similarly comprehensive reference on health effects other than cancer is available. Although general principles exist for approaching other types of risk assessment, there is considerable uncertainty and disagreement about the underlying mechanisms causing effects other than cancer.

2. *Technical Guidelines*

Statements of principle in themselves offer direction for conducting specific risk assessments, but they need to be augmented by more specific technical guidance appropriate to regulatory needs. Attempts at more practical common approaches have therefore evolved in the various regulatory agencies over the last several years. General procedures for estimating risk (mainly in reference to cancer) have been codified in the form of guidelines, which include the following:

Interim Procedures and Guidelines for Health Risk and Economic Impact Assessments for Suspected Carcinogens, EPA, 41 FR 24102 (May 25, 1976);

Scientific Bases for Identification of Potential Carcinogens and Estimation of Risks, Report by the Work Group on Risk Assessment of the Interagency Regulatory Liaison Group, 44 FR 39858 (July 6,1979).

Other guidelines relate to a specific EPA program:

Guidelines and Methodology Used in the Preparation of Health Assessment Chapters of the Consent Decree Water Criteria Documents, Appendix C of Water Quality Criteria Documents: EPA, 45 FR 79347 (November 28, 1980).

Appendix E: Response to Comments on the Human Health Effects Methodology for Deriving Ambient Water Quality Criteria, 45 FR 79368 (November 28, 1980).

In addition, EPA recently published proposed guidelines covering five aspects of risk assessment:

Mutagenicity Risk Assessments: Proposed Guidelines, EPA 45 FR 74984 (November 13, 1980).

Proposed Guidelines for the Health Risk Assessment of Chemical Mixtures and Request for Comments; Notice, 50 FR 1170 (January 9, 1985).

Proposed Guidelines for the Health Risk Assessment of Suspect Developmental Toxicants and Request for Comments, 49 FR 46324 (November 23, 1984).

Proposed Guidelines for Exposure Assessment; Request for Comments, 49 FR 46304 (November 23, 1984).

Proposed guidelines for Carcinogen Risk Assessment; Request for Comments, 49 FR 46294 (November 23, 1984).

To be useful, guidelines must simultaneously balance the need to be comprehensive, specific, and flexible. *Comprehensive* means they should deal with each discrete analytic step of a risk assessment. *Specific* means they must describe, to the extent practical, the scientific basis for each step. And *flexible* means they must allow, and even encourage departure from the general approach if data are available suggesting that an alternative is preferable, or if a single approach is not appropriate to the case at hand.

Further Development of Risk Assessment Guidelines

In light of the NAS recommendations for developing risk assessment guidelines and procedures, EPA reviewed many of the technical issues that constitute the components of a specific risk assessment. These issues are numerous, diverse, and cover a broad spectrum of potential problems. Some of the more important issues that are being examined during EPA's current efforts to develop new or revised guidelines include:

- *Hazard identification:*
  Guidance is needed on the criteria for determining whether a particular agent is causally linked to a particular health effect and for providing guidance on combining the "weight of the evidence" criteria with other elements of the risk assessment.
- *Pathology interpretations:*
  These are important for all health effects, but are especially critical in assessing cancer risk; they relate to the appropriate selection of end-point indicators of disease processes.
- *Partial lifetime exposures:*
  Many environmental situations result in shorter than lifetime human exposures to toxic chemicals. The Agency needs to establish guidance for extrapolating from chronic effects in laboratory animals to sub-chronic effects in humans.
- *How to assess risk from multiple routes of exposure:*
  Guidance is needed on estimating total risk when the individual is subjected to several routes of exposure simultaneously.
- *The role of "structure/activity relationships":*
  Guidance is needed on the extent to which it is valid to base risk predictions in part on comparisons to another substance with similar chemical structure or activity.
- *Risks to sensitive populations:*
  Unlike experimental animals, humans vary greatly in their genetic makeup, age, sex, health, and nutritional status, as well as general environment. Guidelines are needed on how to address these differences, and the extent to which they will affect risk estimates.

To deal with problems like these, the Agency plans to complete new (or revise existing) guidelines on the following topics:

Carcinogenicity

The 1976 Interim Guidelines for Cancer Risk Assessment are being updated in order to reflect later developments in the scientific data base that underlays

the guidelines and the cancer principles in the OSTP documents, and to clarify points that are unclear or have been unresolved in the existing guidelines. The existing guidelines address both qualitative and quantitative aspects of cancer risk assessment.

Mutagenicity

Mutagenicity refers to the potential of an agent to induce changes in human or animal cells so as to produce heritable genetic effects. These alterations may include point mutations (such as changes in the base sequence of DNA) and structural or numerical chromosomal aberrations. Mutations in somatic cells have been linked with the initiation of neoplastic transformation and mutations in the germ cells, which are associated with various types of genetic diseases.

Both the Office of Pesticide Programs and the Office of Toxic Substances currently evaluate mutagenicity data as a basis for possible chemical regulation. While this information is most often used to predict carcinogenic potential, such data increasingly are being used to predict potential for the induction of heritable mutations.

The Agency's existing draft guidelines for mutagenicity risk assessments describe the types of evidence to be weighed in determining the potential mutagenicity of a chemical, as well as quantitative approaches that are appropriate to the estimation of human heritable mutation and disease. In preparing the revised mutagenicity guidelines, the Agency reviewed and updated both the existing test criteria and the system for weighing evidence.

Reproductive Effects

The male and female reproductive systems and the developing fetus are potentially sensitive targets for the action of toxic agents. Developmental toxicity is included in the category of reproductive effects and pertains to teratogenicity as well as other effects such as resorbed fetuses, still-births, spontaneous abortions, and other congenital dysfunctions.

Teratogenic effects encompass an extremely diverse set of impacts that harm the developing fetus and are manifested as congenital malformations (such as cleft palate), developmental malformations, or functional malformations (such as nervous system dysfunction). The Agency has a preliminary document ("Assessment of Risks to Human Reproduction and to Development of the Human Conceptus from Exposure to Environmental Substances," EPA, 1982) outlining major issues for consideration in assessing both teratogenic and reproductive effects resulting from exposure to environmental agents. However, this document does not provide definitive guidelines for assessing such risks to the developing organism. Issues addressed by the November 23, 1984 proposed guidelines include:

Existence of a Threshold: Unlike carcinogens or mutagens, which may be presumed to have some finite probability of an effect at any dose, no matter how small, some teratogens may have an effect only if they exceed a certain level of exposure. Where thresholds are believed to exist, we want to be able to define a no-adverse-effects level, with appropriate safety factors. On the other hand, we also want to provide technical guidance for determining if a threshold does not exist.

Extrapolation Between Species: Inherent interspecies differences complicate extrapolation of animal test data to direct determinations of human risk. For example, aspirin is a fairly powerful rodent teratogen and thalidomide is a fairly weak animal teratogen. The situation is, of course, reversed in humans.

Systemic Effects

In addition to the effects previously discussed in this chapter, exposure to toxic substances can lead to adverse effects on various organs, such as the liver, the kidneys, or the lungs. These effects cover a broad spectrum of graded tissue responses, ranging from small changes in enzyme levels to severe organ dysfunction and debilitation or death of the individual. Thus, some mechanism is needed for interpreting data pertaining to the graded effects observed in a specific organ from exposure to a single toxic substance.

Available scientific evidence indicates that many systemic toxic substances may have thresholds, which further complicates risk assessment. Moreover, the results of the calculations for estimating the threshold can vary depending on which one of the graded responses is used to represent the disease state. For example, if one wants to calculate a threshold for kidney effects due to cadmium exposure, it will make a difference if one looks at the early stages of the disease (i.e., mild cellular changes) or the later stages of the disease (i.e., severe cellular changes and kidney dysfunction).

Current Agency draft guidelines for risk assessment of systemic toxicants only address the estimation of "safe" exposure levels, such as acceptable daily intakes. Further development of these guidelines will focus on the following key issues:

- Extrapolation of health effects in test animals to health effects in humans;
- Extrapolation of dose in test animal to equivalent exposure in humans;
- Extrapolation between different routes of exposure in test animals and humans;
- Ranking of graded toxic effects.

Assessment Methods for Chemical Mixtures

Most risk assessments address the health impact of individual chemicals; the Agency has an increasing need to know the risks associated with chemical mixtures. The hazardous waste and Superfund programs, for instance, deal more frequently with exposures to mixtures than exposure to single chemicals. Also, people are typically exposed not to isolated pollutants, but rather to a complex, dilute mixture of many substances.

Considering how many chemicals there are in the environment, there is a virtually endless number of combinations that could constitute potential synergisms or antagonisms. In only a few cases does concrete evidence exist of what these are. In the absence of such empirical data, an additive method, which simply sums individual chemical effects, is used. As more is learned about the effects of chemical mixtures, the additivity approach may require modification. The guidelines proposed in January 1985 describe a hierarchy of procedures for estimating health risk, based on the nature of the available data. The possible data types include: (1) specific toxicity data on the mixture itself, (2) toxicity

data on a chemically similar mixture, (3) data on interactions of some of the components of the mixture, or (4) quantitative toxicity data on single chemicals within the mixture.

Exposure Assessment

Given the absence of complete environmental data ambient levels of pollutants must be estimated, using the following information sources, singly or in combination:

- Field monitoring;
- Mathematical modeling;
- Measurements of actual tissue concentrations of pollutants;
- Laboratory modeling data.

To estimate human uptake of some substance, the first step is to determine how many people are exposed through the various relevant environmental pathways—in the air, soil, water, drinking water, or food. The next step is to calculate the rate of uptake through breathing, eating, drinking, or absorption through the skin. The new exposure guidelines will review and modify as needed the standard factors used in estimating exposure. These factors for humans include standard body weights, breathing rates, and fluid and food intakes. In the past, some differences among programs in estimating such factors, while not great, have contributed unwanted variation in the results of risk assessments. The guidelines will address statistical approaches designed to estimate the degree of uncertainty associated with different modeling assumptions.

As noted above, proposed quidelines for five of these six areas have recently appeared in the *Federal Register.* EPA is continuing to revise those guidelines in the light of public comments and to develop guidelines for systemic toxicants.

The Importance of Scientific Forums

EPA has established a Risk Assessment Forum to provide an institutional locus for the resolution of significant risk assessment issues as they arise and to ensure that Agency consensus on such issues is incorporated into the appropriate risk assessment guidelines. The scientific basis for risk assessment changes rapidly, and formally updating the guidelines is expensive and time-consuming. The Forum will provide Agency scientists with a regular time and place to discuss problems of risk assessments in production. Peer advice and comment of this type will help improve the quality of risk assessments, with associated savings in time and resources. The Forum will also monitor scientific developments and make recommendations about when guidelines updates are needed and what form they should take. Updating the guidelines is not simply a matter of determining which procedures are out of date and recommending substitutes. Minor updates along these lines can continue to be done informally. More difficulty arises when a new scientific finding comes to light that challenges one of the major principles underlying the operational guidelines.

The Forum will meet regularly to discuss these issues and will advise the Administrator and Deputy Administrator on precedent-setting cases and important science policy concerns.

The Assistant Administrator for the Office of Research and Development is responsible for implementing this initiative. The membership includes senior scientists and managers involved in risk assessment from each of the program offices. The formal responsibilities of this Forum are to assist programs in implementing guidelines and to ensure appropriate revisions to guidelines as new knowledge becomes available. Perhaps most important, the Forum will serve in the context in which risk assessment disagreements and uncertainties can be reviewed and resolved.

Risk Management: Goals and Applications

The term "risk management" represents the complex of judgment and analysis that uses the results of risk assessment to produce a decision about environmental action. The term was originally meant to distinguish the political, economic, and social aspects of decision-making from the scientific exercise involved in the assessment of risk (the point being that scientists performing such calculation should not be under pressure to trim results to suit policy concerns). In the last year or so it has come to stand for a wider and potentially more useful concept, as the Agency has begun to implement the NAS definition.

Risk management is the way EPA is coping with the increasing complexity of its mission. It represents a return to first principles. The general mission of EPA is to protect human health and other environmental values from the harmful effects of pollutants. Since such pollutant effects are typically ringed with at least some uncertainty, it follows that EPA is largely concerned with protecting against pollutant-related *risk*, here defined as a measure of the probability and severity of such harm. Every direct action EPA takes can be associated with reduction in some risk to health or environmental value, and risk reduction may thus be considered a common measure of all Agency action.

If risk reduction is one of EPA's main reasons for being, then risk management can be defined as determining and accomplishing those actions that will reduce risk to the greatest degree given any particular level of resources (meaning Agency resources and those of society in general). The resource consideration is vital here. One can argue about how much should be spent on environmental protection, but at some point the commitment of resources for any social purpose has a finite limit. If the number of potential risk targets is very large in comparison to the number that can be realistically pursued, then some rational method of choosing which risks to reduce and deciding how far they should be reduced is indispensable.

This is risk management. It is important to keep in mind that *while individual risk management decisions may be seen as balancing risk reduction against resources, the system as a whole is also designed to balance risk against risk.* In other words, it is essential that we control the worst risks first; failure to do so means that the total amount of harm that we eventually prevent is smaller than the amount we might have prevented.

In making such balances, the risk management approach regards risks of the same type (e.g., risks of a particular disease) as comparable regardless of their exposure routes. This makes sense because risk may be transferred around the environment and among environmental media by natural processes or by pollution control itself, and the idea, of course, is to reduce the total risk in the whole environment.

In practice, however, this is extremely difficult to do, as EPA operates under nine different statutes, each directed at a different form or locus of pollution. These statutes not only establish the values that the Agency must protect (and these naturally differ among the statutes), but in the case of risk to human health they also often appear to direct different approaches to risk reduction. Briefly, there are two broad groups of statutory mandates to which any risk management approach must be adapted. In the first (e.g., Toxic Substances Control Act), explicit balancing of risks against benefits or costs of control is authorized or required. In the second group (e.g., the Clean Air Act), a standard that protects human health or some other value must be established or some particular level of technical control must be applied. Cost considerations may be specifically prohibited during the development of the protective standard. Here risk management means finding the most efficient way of achieving the standard, while at the same time assuring that policies designed to remove specific pollutants under these laws do not have perverse effects, such as transferring an equal or increased risk to another environmental medium.

The Agency must, of course, enforce the laws as they are presently written. At the same time EPA wants to select, across all programs, the set of actions that most efficiently reduces environmental risk as a whole. This is a difficult task, but it can be done. Indeed, it must be done if one of the primary purposes of EPA's existence is to be achieved —the development of a coherent environmental program out of an array of disparate legislative mandates.

Elements of Risk Management: Setting Priorities and Making Choices

In operation within the Agency, the risk management approach has two major ends: setting priorities among the risks presented by pollution that are amenable to control by EPA; and choosing the appropriate reduction actions for the risks so selected. Obviously, these ends have been addressed in one way or another since the beginnings of the Agency: programs have set priorities and instituted controls, and pollution has been reduced. What EPA's current risk management approach does is require that these traditional activities be expressed, where feasible, in terms of risk reduction.

In the case of priority setting, this risk-based management would enable EPA to ensure that the Agency *as a whole* had an agenda of potential activities directed against the worst set of risks susceptible to its control. Priority-setting, in turn, is important because historically the Agency's agenda has been set less by systematic analysis than by direct public pressure in response to the environmental issues of the day, often embodied in court orders, legislative mandates, and merely random action. To a certain degree, this reactive mode of behavior is inevitable. But it would be of tremendous advantage to the cause of real risk reduction if the Agency were able to make the case that its assemblage of proposed risk-reduction targets represented a demonstrably greater threat than any other.

In choosing control actions, the Agency's discretion regarding the balancing of risks with other factors varies with the applicable statutes. Nevertheless, a certain amount of balancing goes on in virtually every important Agency control decision. Historically, this kind of judgment has taken place at many different levels of the Agency; when policies or regulations reached the final stages,

it was often impossible to establish in any meaningful way the nature of the judgments that had gone into them. In contrast, in the risk management approach it is of the essence that such judgments be made as explicitly as possible, and that the whole array of considerations that establish an Agency decision about controlling some risk be presented in a comprehensible fashion to senior EPA management.

In general, the balancing that goes into such risk management decisions includes consideration of at least three major components. The first is the harmful effect of the pollutant(s) proposed for control. When the effect is on human health this factor may be expressed as a numerical risk estimate, but EPA must control many harmful effects that cannot be so expressed.

Particularly difficult issues of value arise in connection with nonhealth effects. While we can quantify certain "benefits" that accrue when such effects are reduced (e.g., increased fishing days, reduced materials damage), clearly some values defy this approach yet are obviously important and, indeed, are built into the language of much of the legislation. The values include such considerations as the value of an unused aquifer or of the preservation of pristine wilderness areas. It is important to remember that risk management includes making judgments about values that do not involve human health risk and frequently cannot be quantified under the present state of the art.

The effects factor is therefore not a simple one. Besides the many complexities involved in assessing the extent of exposure and the severity of hazard (which have been discussed elsewhere in this report), the balancing decision should consider the distribution of the effect in terms of how many people it affects over how wide a geographic area, the reversibility or persistence of the effect, and the impact of the decision on the long-term health of ecological systems.

The second factor may be called "cost," although it is not simple either. It may include the cost of pollution controls, the relinquished benefits of using a pesticide or other toxic chemical, the danger of displacing private sector initiatives, or the impact of some control option on employment, firms, or communities.

The third factor combines the effect of the quality and extent of the data base for the decision, and the effects of the many assumptions involved in the risk assessment. It is essentially a measure of confidence. The Agency almost always acts under conditions of uncertainty, but that uncertainty has an enormous range. Similar cost-effect relationships may look very different to the risk manager if they differ substantially in the weight of evidence tying pollutant to effect, or control strategy to reduction in risk.

Cost and effect as defined here are, of course, related; examination of that relationship is at the heart of risk management. The relationship is usually established by the technical means of control, with higher control costs associated with greater reductions in the harmful effect, typically along a curve of declining efficiency. That is, the last increments of pollution control are far more expensive than the first. For example, it may cost as much to get from 95 to 99 percent removal of some toxic as it did to get from zero to 95 percent.

Analytic Tools

A number of analytic tools aimed at exploring this relationship may be briefly distinguished:

Benefit/Cost Analysis: This approach weighs the costs of control, explicitly and directly, against the monetized benefits of control—the avoidance of disease and the attainment of other social goods (e.g., increased visibility, reduced soiling and materials damage, etc.). Benefit/cost analysis is of greatest use when all factors affected by a decision can be accurately represented in dollars. This is often difficult to do, since the Agency is frequently concerned with protecting such things as human life and the stability of ecosystems—social values for which there is no market price or for which current procedures for finding "shadow prices" are bitterly controversial. In areas where this is not a constraint (cost of control vs. avoided crop or materials damage, for example), benefit/cost analysis provides a structured way to balance effects and costs directly.

Risk-Benefit Analysis: Like benefit/cost analysis, risk-benefit analysis balances one aspect of a decision against another, but without reducing all factors to commensurate units. Risks may be expressed in whatever terms are appropriate—estimated cases of disease, disruption to animal life, and so forth. Benefits generally include net monetary gains, such as the value of increased crop yield minus the costs of applying a pesticide. Risk-benefit analysis is particularly useful where the Agency has discretionary authority to determine a balance among several competing social values that cannot be expressed in common units, as in the pesticide program.

Cost-Effectiveness Analysis: Unlike the other two approaches, cost-effectiveness analysis begins by accepting the desirability of a particular control action. It does not weigh risks against benefits or monetize benefits; it only looks for the least-cost path to achieve a given goal, such as the achievement of a protective standard. For example, if a number of controls are available to remove some pollutant from the atmosphere down to a certain predetermined level, the cost-effective solution is the one that does this most cheaply.

Cost-effectiveness analysis is at present the most widely used tool at EPA, since so much of the Agency's work is aimed at implementing pollution standards. It is more straightforward in application, since it does not entail quantification of benefits: one calculates the cost per unit of reduction of pollution or risk associated with each available option, and, all other things being equal, picks the lowest. But cost-effectiveness analysis can also be used to compare different ways of obtaining some specified degree of risk reduction.

While these types of analysis could be part of any risk management exercise, it is important to note that risk management does not, as some critics have implied, demand the monetization of the social values the Agency is charged with protecting. Risk management in the EPA sense is the expression of the value of the societal and governmental expenditure represented by an environmental control action. The value expressed could be relatively easy to quantify (e.g., reduction in materials damage or cases of particular diseases) or difficult (e.g., protection of sensitive ecosystems or future ground water use). Risk management is a way of explaining the logical connections between a body of research, the application of certain economic, political, and social values, and the achievement of some environmental result.

Comparability and Consistency

Inherent in risk management is the idea of comparability. EPA has a number

of goals, some of which may conflict. For example, deep ocean dumping of sewage sludge may reduce human health risk in comparison with incineration or land spreading, but may have adverse effects on marine ecosystems, which are valued in their own right, and on the food chain. Assigning resources on the basis of the varying importance attached to the attainment of different goals and coordinating efforts that are driven by apparently conflicting goals, are both susceptible to a risk management approach. Indeed, it is hard to see how they could be done effectively otherwise.

Also inherent in risk management is the principle of consistency. Since pollution control (and hence risk reduction) is an incremental process, with the later increments typically costing more to achieve than the earlier ones, a regulatory agency may be faced with a number of potential actions with widely differing marginal costs for the same or similar risk reduction.

Marginal cost consistency may conflict with another sort of consistency of result. It may be desirable to place an absolute limit on the risk experienced by any particular individual from environmental contaminants, or, in cases where residual risks are unavoidable, it may be preferred to achieve a consistent level of post-regulatory risk in all control actions.

But such proposals, however attractive they may be in terms of rational management, ought to be constrained by a sense of the limits of quantification methods. Some important things cannot be quantified but are nonetheless real. EPA must respond to public fear and concern, for example, whatever our analysis shows. Protection from fear is part of EPA's job. Public confidence is an essential part of EPA's equipment. The Agency will not be allowed to undertake risk management if this confidence fails. Strictly quantitative models usually do not make allowances for such imponderables as public confidence; this is why risk management at EPA is not just numbers. And, of course, limitations because of the uncertain nature of environmental research data mean that care must be taken not to read into such numbers more precision than their origins warrant.

The limitations noted above make it unwise to establish formal trigger points for Agency actions. It may not be appropriate, for example, to settle on a single *de minimis* level of risk that would be required before regulatory action is considered. Measures of consistency of result, such as marginal cost per case avoided, are useful guides; they should not be made into rigid grooves that might deprive the Agency of the flexibility it needs to carry out its complex missions.

On the other hand, consistency of *approach* in making decisions based on risk, cost, and uncertainty is essential. The management of EPA needs to know how the actions of the various programs actually work *all together* to reduce the harm done by pollutants. Management should also have the opportunity to compare the relative impact of the programs.

In order to determine current risk management approaches the Toxics Integration Task Force carried out a study of how the various considerations that make up risk management were used in 27 recent Agency regulatory actions. This study was based on data submitted by the program offices, which included such factors as: the justification for action; the origin of the risk analysis and whether the effect involved was health or environmental; the data on hazard and exposure; the degree of uncertainty in the relation between exposure to the pollutant and the risk calculated; the sources to be controlled and their

significance in relation to any other sources of the same kind of risk; estimated levels of pre- and post-regulatory risk; the benefits of control and how they were expressed (e.g., marginal cost per case avoided, reduction of exceedances of standards); and intermedia transfer of pollution attributable to controls required by the regulation.

The Agency showed significant variations across programs in the way they used these sorts of data and in the way risk management was actually carried out. As mentioned earlier, risk management implies some balancing of values; the statutes differ in the way they direct EPA to balance values, particularly in the extent to which control costs may be considered in establishing allowable or "safe" levels of a pollutant. In practice, however, some form of balancing is found in all EPA programs, although the study made clear that it does not always occur in ways that can be presented simply.

Part of the difficulty in comparing risk management across programs arises because risk reduction does not even appear as an explicit concept in several of EPA's authorizing statutes. Thus, when applied to a program that protects mainly environmental values via technology-based standards, such as the Effluent Guidelines Program, risk management means something different from what it means in connection with a program (like the Hazardous Air Pollutants Program) focused on human health protection. Similarly, it is easier to present risk management decisions in the case of a national program to control a single substance than when, as in the Resource Conservation and Recovery Program and Superfund, EPA is charged with controlling complex waste streams. Further, programs responsible for cleaning up wastes (e.g., Superfund) or for controlling useful substances that are poisonous (pesticides and toxic industrial chemicals) have ways of expressing risk management information that are different from those used by programs that impose pollution controls in the strict sense.

Differences in mandate and program structure, however, do not excuse the Agency from developing consistent approaches in the areas of risk management to which the statutes are indifferent. The retrospective study found that the Agency as a whole had no generally accepted way of expressing the degree of confidence in the pollutant-effect connection or of dealing with intermedia transfer of risk. Moreover, despite their historic differences in approach, EPA programs are part of a single national effort embodied in a single Agency. The Agency in turn must respond to a basic requirement of good public policy: *to establish the connection between some expenditure and some recognized public good.* Most regulations cost something, whether expressed in dollars spent by industry or in terms of the consequences of doing without a useful product. All regulations use up Agency resources. Agency management needs to know if the total of Agency and societal resources devoted to the prevention of harm to human health and the environment is being applied efficiently.

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Case Studies

1. BENEFIT-COST ANALYSIS: LEAD IN GASOLINE

EPA's recent rulemaking on lead in gasoline illustrates the valuable role that

risk management and risk assessment techniques, in particular, benefit-cost analysis, can play in identifying and designing solutions for serious health and environmental problems. The lead-in-gasoline rulemaking is particularly instructive because it clearly represents a case where careful quantitative analysis pointed the way to significant action in the absence of statutory deadlines or public pressure.

Lead in gasoline has been regulated by EPA for over a decade, with the most recent prior rulemaking completed in October 1982. Less than a year later, however, Agency officials asked the Office of Policy, Planning and Evaluation to investigate the merits of additional controls, based on concerns about the misuse of leaded gasoline in vehicles that require unleaded gasoline to protect their pollution control catalysts ("misfueling") and the potential threat posed to children's health by lead.

The initial analysis, released for comment in March 1984, showed that despite the substantial lead reductions achieved through earlier rulemakings, further tightening of the lead limit would yield major health gains, with benefits far in excess of the costs. That report helped spur intensive development of a new rule, proposed in August 1984, less than two years after the previous rulemaking on lead in gasoline had been concluded. Additional analysis demonstrated the feasibility and desirability of setting a very tight phasedown schedule. The final rule, issued in March 1985, was even more stringent than the original proposal; it requires that lead in gasoline be reduced from 1.1 grams per leaded gallon (gplg) to 0.5 gplg by July 1985 and to 0.1 gplg by January 1986. The Agency did not ban lead in gasoline altogether because of continuing concerns that a minimum amount of lead might be needed to protect certain older engines designed to use leaded gasoline. Based on additional health studies and evidence that lead may be less essential for older engines than previously thought, however, the Agency is now considering additional steps to reduce the health threat posed by lead in gasoline, including a possible ban as early as 1988.

Costs of Reducing Lead

Since the 1920s, refineries have added lead to gasoline as an inexpensive way of boosting octane. To meet octane requirements with little or no lead, refineries must engage in additional processing, which raises costs, or use other additives, such as MMT or alcohols, which are more expensive than lead.

EPA, using a computer model of the refining industry developed for the Department of Energy, estimated the cost of the rule. This model, which is similar to others developed by refiners themselves to help increase the efficiency of their operations, represents individual processing units in the industry by a series of mathematical equations. These equations show how various inputs can be transformed into different end-products at varying costs and the constraints on industry capacity. Given a set of final products, the model finds the least-cost method of production.

To estimate the costs of the rule, EPA first ran the model specifying the current lead limit of 1.10 grams per leaded gallon (gplg) and computed the cost of meeting demand for refined petroleum products. It then reran the model specifying a tighter lead limit and recomputed the overall cost. The difference

between the costs at the two lead limits is the estimated cost of the tighter standard. Many constraints were added to the model to ensure that the cost estimates were not unrealistically low.

Based on this analysis, EPA's best estimate is that the rule will cost less than $100 million in the second half of 1985 (when the standard will be 0.5 gplg) and just over $600 million in 1986 (the first year that the 0.1 gplg standard will take effect). The model also showed that demand for gasoline and other petroleum products could be met with existing refining equipment and without any increase in imports.

The Agency also ran extensive sensitivity analyses that tested the effect of more pessimistic assumptions, such as unexpectedly high demand for high-octane unleaded gasoline, increased downtime for refining equipment, and reduced availability of alcohol additives. These sensitivity analyses showed that the 0.1 gplg rule could be met under virtually all conditions, and that feasibility would be in doubt only if many adverse conditions occurred simultaneously—an extremely unlikely possibility.

Benefits of the Rule

Benefits were estimated in several major categories: children's health and educational effects associated with lead exposure; damages caused by excess emissions of pollutants from misfueled vehicles; and impacts on vehicle maintenance and fuel economy. In addition, EPA also used the recently published studies on the relationship between blood lead and blood pressure to make preliminary estimates of some of the health benefits that adults might reap from the rule. Although gaps in the data made it impossible to quantify all of the likely benefits in each category, the estimates were still substantial, far in excess of the costs.

For each benefit category, EPA first estimated the impact of reduced lead in physical terms. In the case of children's health effects, for example, it used statistical studies relating gasoline lead to blood lead to project how the numbers of children with elevated blood levels would change if lead in gasoline were reduced. To estimate the impact of reduced misfueling on emissions of conventional pollutants (hydrocarbons, nitrogen oxides, and carbon monoxide), it used data on the current extent of misfueling and increased emission rates in misfueled vehicles, and then combined those with projection of miles driven by vehicles of different types.

Lead, together with the scavengers added to prevent excessive lead deposits in engines, corrode engines and exhaust systems. Based on several studies comparing matched vehicles on leaded and unleaded gasoline, EPA estimated the impact of the rule on the frequency of exhaust system replacements, oil changes, and spark plug changes. The refining processes used to replace the octane now supplied by lead also will improve fuel economy by producing gasoline with a slightly higher energy content.

The preliminary estimates of blood-pressure-related benefits relied on a recently published study that estimated the relationship between blood lead and blood pressure. Combining that study with others that link gasoline lead to lead in blood, EPA was able to predict the impact of the rule on blood pressure and the number of hypertensives. Data from large epidemiological studies of

cardiovascular disease were then used to estimate reductions in the numbers of heart attacks, strokes, and deaths from all causes related to blood pressure. Because the best data were available for white males aged 40 to 59, the estimates were restricted to that group.

Table 4–1 summarizes several important nonmonetary measures of the benefits of the phasedown for the years 1985 to 1987. Note that the estimates for 1985 are for the 0.5 gplg standard and only cover the second half of the year. The estimates for 1986 and 1987 are for the 0.1 gplg standard and cover the full years.

The estimates in Table 4–1 indicate substantial benefits, but do not include the maintenance benefits, and it is difficult to compare them to the costs, measured in dollars. Thus, the next step was to value the benefits in dollar terms. For the maintenance benefits, this step was relatively easy; it involved, for example, determining the average cost of an oil change.

For the other benefit categories, however, valuation is much more difficult and controversial. How much is it worth to prevent a child from having a dangerously high level of blood lead, or an adult from suffering a stroke? For the children's health effects, the Agency took a conservative approach, valuing effects only for children brought below the CDC level of 25 ug/dl. Even for those children, the estimates were restricted to the cost of recommended medical tests and treatment and to the cost of compensatory education for a subset of children over 25 ug/dl who may suffer significant losses in their learning ability.

EPA estimated the benefits of reduced emissions of conventional pollutants in two ways. The first involved direct estimation of some of the health and welfare effects associated with these pollutants (e.g., crop losses and days of illness). The second method valued the emission reductions based on the implicit cost per ton controlled of the emission control equipment destroyed by misfueling. The final estimate, used in computing total and net benefits, was the average of the two different methods.

For the adult blood-pressure-related benefits, reductions in hypertension and related nonfatal diseases were valued on the basis of savings in medical costs and lost wages due to illness. Valuing reductions in the risk of death is difficult and controversial, with a wide range of estimates in the literature. EPA's Regulatory Impact Analysis (RIA) guidelines, for example, suggest a range of $400,000 to $7 million per statistical life saved. The RIA uses a point estimate from the lower end of that range, $1 million per case.

Costs and Benefits of Alternatives

Table 4–2 shows the monetary estimates of costs and benefits for 1985 to 1987. Note that the monetized benefits exceed the costs by three to one if the preliminary blood-pressure-related benefits are not included, and by better than ten to one if they are included.

The estimates in Tables 4–1 and 4–2 assume that the 0.5 gplg rule will not have an impact on misfueling (because its impact on the price of leaded gasoline is likely to be trivial) and that the 0.1 gplg limit will eliminate 80 percent of misfueling. EPA also estimated the costs and benefits for other possible misfueling rates. In addition, it considered the impacts of a wide range of alternative phasedown schedules (in particular, whether the phasedown should start in 1985 or 1986, and how quickly it should be tightened to 0.1 gplg).

TABLE 4-1. NONMONETARY MEASURES OF THE BENEFITS OF LEAD PHASEDOWN

	1985	1986	1987
Reduction in number of children above 25 ug/dl blood lead	64,000	171,000	156,000
Reduction in tons of emissions of conventional pollutants			
Hydrocarbons	0	244,000	242,000
Nitrogen oxides	0	75,000	95,000
Carbon monoxide	0	1,692,000	1,691,000
Reductions in blood-pressure related effects in males aged 40–59			
Hypertension	547,000	1,796,000	1,718,000
Myocardial infarctions	1,550	5,323	5,126
Strokes	324	1,109	1,068
Deaths	1,497	5,134	4,942

Source: U.S. Environmental Protection Agency

TABLE 4-2. COSTS AND BENEFITS OF LEAD PHASEDOWN (MILLIONS OF DOLLARS)

	1985	1986	1987
BENEFITS			
Children's health effects	$223	$600	$547
Conventional pollutants	0	222	222
Maintenance	102	914	859
Fuel economy	35	187	170
TOTAL BENEFITS EXCLUDING BLOOD PRESSURE	360	1,924	1,799
NET BENEFITS EXCLUDING BLOOD PRESSURE	264	1,316	1,241
ADULT BLOOD PRESSURE BENEFITS	1,724	5,897	5,675
NET BENEFITS INCLUDING BLOOD PRESSURE	1,988	7,213	6,916

Source: U.S. Environmental Protection Agency

The estimates in Tables 4–1 and 4–2 assume that the 0.5 gplg rule will not have an impact on misfueling (because its impact on the price of leaded gasoline is likely to be trivial) and that the 0.1 gplg limit will eliminate 80 percent of misfueling. EPA also estimated the costs and benefits for other possible misfueling rates. In addition, it considered the impacts of a wide range of alternative phasedown schedules (in particular, whether the phasedown should start in 1985 or 1986, and how quickly it should be tightened to 0.1 gplg).

Regardless of the assumption about misfueling and whether the blood-pressure-related benefits were included, EPA's analysis found that net benefits (benefits minus costs) were maximized at the tightest of the alternative standards considered, 0.50 gplg for the second half of 1985 and 0.10 gplg for 1986 and subsequent years. That is, tightening the schedule increased benefits substantially more than it increased costs. Together with the unquantified benefits, these results indicated that rapid reductions in lead in gasoline are amply justified.

The experience with lead in gasoline illustrates the very useful role that benefit-cost analysis and other risk-management techniques can play in designing regulations that target Agency and societal resources where they yield the greatest gains for health and the environment. Although many other factors were important in the Agency's decisions, it is clear that the very large health gains estimated as part of the benefit-cost study helped speed up the regulatory process and contributed to the rapid phasedown schedule that was promulgated.

2. THE APPLICATION OF RISK ANALYSIS TO AIR TOXICS ISSUES

If "the proof of the pudding is in the eating," then the real worth of risk assessment is revealed in situations when it is put into practice. One recent application of the techniques of risk assessment suggests the validity of the old adage. In this situation, risk assessment ideas were used to gain insight into the nature and extent of the air toxics problem nationwide.

The Air Toxics Problem in the United States

An issue of continuing concern to EPA is the environmental hazard represented by toxic air emissions. These include substances that have the ability to cause cancer or other serious illness when inhaled. Early in 1984, EPA began a comprehensive analysis of this problem.

This effort had several outcomes. A major study was completed entitled "The Air Toxics Problem in the United States: An Analysis of Cancer Risk for Selected Pollutants." A follow-up study was undertaken to determine how much of the air toxics problem could be controlled through existing EPA programs. Most important, a new air toxics strategy, approved in principle by the Administrator in February 1985, was developed, based to a large extent on the results of these risk analyses, and submitted for public comments in June 1985.

The new air toxics strategy has three main parts: (1) direct federal regulation of significant nationwide problems; (2) state and local control of significant pollution problems that are not national in scope; (3) increased study of geographical areas subject to particularly high levels of air pollution, possibly because of the presence of many sources. Each of these parts of the national strategy found some support from the risk analyses conducted as part of the studies of the air toxics problem. In particular, the strategy addresses sudden and accidental releases, in addition to permitted emissions.

Recent Studies of the Air Toxics Problem

The initial study of the air toxics problem looked at 42 compounds and attempted to determine how much risk each of these represented when emitted

into the air. Because of the difficulty in pinpointing other health effects, cancer became the focus of the study. Using several approaches, the study then attempted to determine how many people were exposed across the country to these toxic compounds. By combining an estimate of the risk associated with each compound with the amount of national exposure, the study was able to estimate the long-term cancer incidence associated with all these compounds together (a 70-year timeframe was used to approximate "long-term").

This analysis suggested that the air toxics problem was complex and caused by many pollutants and sources. Moreover, the problem appeared to vary significantly from city to city, and even within a city.

The study seemed to suggest that pre-existing EPA air toxics strategies, which focused on regulating pollutant-by-pollutant and on federal establishment of national emission standards, approached the problem too narrowly to be effective. On the more positive side, a comparison of air quality data for 1970 and 1980 showed that significant reductions in national cancer incidence related to air pollution has occurred during the past decade, apparently related to more general air pollution programs such as those for control of criteria pollutants (i.e., those pollutants specifically listed in the Clean Air Act, such as particulate matter and ozone).

These results were further refined in the follow-up to the original study, which was designed to examine, in detail, the controllability of the air toxics problem in five cities: Baltimore, Baton Rouge, Los Angeles, Philadelphia, and Phoenix.

The controllability study focused on 14 compounds identified in the original study as presenting the greatest cancer risk to the general population. As in the original study, cancer became the indicator of health effects.

For each of the 14 compounds, the major emission sources were identified in each of the five cities. Human exposure modeling was used to determine the degree of risk experienced by the populations of the selected areas and the cancer incidence expected from this risk. A first look at the controllability of this air toxic problem in these cities was obtained by assuming full implementation of the criteria pollutant program within EPA. This total program has several parts, including national emission standards and detailed State Implementation Plans (SIPs) for attaining these standards. In addition, New Source Performance Standards are established for each newly built or modified source of pollution.

While the results are still preliminary, they do, nonetheless, support the general thrust of the new air toxics strategy. They imply that the continuing criteria pollutant program will be less effective on air toxics than in the past and will reduce the incidence associated with the 14 compounds used in this study over the next 10 years by only about 10 to 15 percent (17 percent from the 1980 base).

The initial results are interesting in other ways. By far, the greatest incidence of cancer is associated with mobile (vehicles) or area sources (numerous small pollution sources, e.g., woodstoves). About 75 percent of the air toxics cancer incidence, assuming full implementation of the criteria pollutant program, is associated with area sources, such as woodstoves or road vehicles. In contrast, point sources of pollution (large, readily identified sources of pollution, such as utility boilers and steel plants) account for relatively little of the total incidence.

These findings support the thrust of the new air toxics strategy in several ways. First, they do suggest that the health problems of air toxics may indeed require a targeted strategy to make best use of available resources. Second, the data suggest that additional focus on small and nontraditional sources may be most beneficial to the general public health. Wood smoke, road vehicles, waste oil burning, and gasoline marketing, for example, apparently are deserving of increased attention.

A risk assessment analysis has been useful not only to highlight what remains to be done to deal with the problem of air toxics but also to indicate what has already been accomplished. This facilitates a strategic transition to put more emphasis on the complex problems of area and mobile sources, as well as on major point sources.

3. INCINERATION AT SEA

Each year, industry in the United States generates more than 70 billion gallons of hazardous waste, which must be safely managed through treatment, storage, or disposal. EPA's regulatory, permitting, and enforcement programs are gradually restricting the use of management practices insufficiently protective of the environment and human health. One effect of this is to reduce the available capacity for managing hazardous waste over the short-term.

Incineration is a technology that offers several advantages over some other waste management practices and may help to meet the anticipated need for greater treatment and disposal capacity. However, public opposition to the permitting of new incineration operations has been strong. In response to the combination of perceived benefits and public concerns, the Deputy Administrator of EPA requested an assessment of incineration.

Between 1974 and 1982, EPA issued permits for four series of burns conducted by the *Vulcanus* incinerator ship: three in the Gulf of Mexico and one in the Pacific Ocean. In the early 1980s, public opposition to incineration at sea intensified. EPA committed not to issue further operating permits for incineration at sea until it had reconsidered and revised its regulation for this practice. To inform these regulations, EPA undertook a number of studies, including one that generally assessed the potential of land and ocean-based incineration for disposing of liquid organic hazardous wastes and their advantages and disadvantages. The central focus was the detailed comparison of land-based and ocean incineration.

Results of the Comparative Risk Assessment

As part of its study of incineration, EPA developed a risk assessment case study, which compares the human and environmental exposure and effects likely from releases of land-based versus ocean incinerators. The study integrates existing information and adds new analyses developed from existing methods and data. No new primary research was completed, so conclusions are limited by the availability and quality of information on emissions, transport, fate, and effects.

Incineration Systems Considered: The study separated land and ocean-based

incineration systems into three and four separate physical components, respectively. Both systems include land transportation, transfer and storage operations, and incineration. The ocean incineration system also includes an ocean transportation step.

The ocean-based system considered has a configuration similar to that proposed by Chemical Waste Management, Inc. (CWM), to operate the *Vulcanus II* from Mobile, Alabama, to the Gulf of Mexico burn zone. However, the study assumes that an integrated storage and transfer facility is located at the port. The land-based system is not modeled on any single incinerator, but combines characteristics of several existing commercial facilities. Since the systems reviewed are generic and not specific, the results of this effort are not sufficient to determine the risks associated with any specific land or ocean-based incineration proposal.

The study does not examine releases on land from major accidents involving fire or explosion at storage facilities. The probability of such events occurring is very low, and since both systems require similar storage facilities, the potential for events of this type would be the same for both systems. The study assumed that incineration would occur for two simplified waste streams with single hazardous constituents: one containing 35 percent polychlorinated biphenyls (PCBs) by weight, and a second containing 50 percent ethylene dichloride (EDC) by weight.

Quantities of Waste Released: The starting point for the analysis was to determine the statistically expected amount of pollutant released from accidental spills and air emissions. Considering all releases from each component of the incineration systems and for both waste streams, the transportation and handling components accounted for less than 15 percent of expected releases, while incineration stack releases accounted for more than 85 percent.

The analysis of land transportation considers two types of potential losses—spills from vehicular accidents and spills from enroute container failures. The study's estimates of spills are based on U.S. Department of Transportation (DOT) data pertaining to all tank trucks carrying hazardous materials. Use of these data with the case study assumptions regarding miles traveled indicates that accidents releasing any cargo are expected to occur on the average once every four to five years, and container failures once every three to four years. Hazardous waste services firms supplied information that indicates that the DOT average accident rates are higher than those actually experienced by the firms. This is perhaps due to special management practices and the use of stainless steel tanks more resistent to rupture than aluminum tanks. The expected annual releases estimates of 2.1 and 2.7 metric tons per year for the PCB and EDC wastes represent, on average, about 0.5 percent of annual transportation-related releases of hazardous materials in EPA Region IV.

The analysis of transfer and storage considers three types of releases: spills when unloading wastes from tank trucks; spills from equipment at waste transfer and storage facilities; and fugitive emissions from transfer and storage. Spills from transfer and storage components are infrequent events, estimated to occur at a rate of about .04 to .05 per year for transfer of wastes from tank trucks, a rate of .03 to .04 per year for equipment and storage tanks, and a rate of .002 to .003 per year for the hose loading wastes to the ship in the ocean system. Spills of these types are likely to be contained at the facility. Fugitive emissions

would also result in expected releases of 0.6 to 0.7 metric tons per year, resulting in total expected releases of 1.1 to 1.2 metric tons from transfer and storage. The total number of spills from transport and handling would represent, on average, less than 0.1 percent of the number of spills of hazardous materials likely from fixed facilities in EPA Region IV.

About 320 voyages of incineration ships in the North Sea have been made since 1972, and no casualties of spills have occurred. Estimates for spill rates used in this study are based on the worldwide historical record of tank ships of a similar size and class. The historical rates were adjusted to take into consideration the design of the *Vulcanus*, operating restrictions imposed by the Coast Guard, and the soft bottom conditions in the Gulf of Mexico.

Spills from the vessel would be very infrequent. The estimate is that the frequency of all spills for the *Vulcanus* is about one per 1,200 operating years. However, the frequency of spills estimated for any particular location is less. For example, the overall spill rate for the pier and harbor area is about one per 3,000 operating years; for Mobile Bay, about one per 10,000 operating years; for the coastal area, about one per 4,000 operating years; and for the burn zone, about one per 6,000 operating years. These estimated spill rates are for all sizes of spills. Spills involving two or three or more tanks would be extremely unlikely events. For example, the estimated rate for spills in Mobile Bay involving two tanks is about one per 67,000 operating years, and about one per 200,000 operating years for spills in the Bay involving three or more tanks.

The tonnage carried by the *Vulcanus* is small in comparison to commercial shipments of petroleum and hazardous substances in the Gulf area. For example, the cargo carried by the *Vulcanus* has a lower spill rate than other vessels, and the potential for releases from the Vulcanus is only about 0.002 percent of that from ongoing shipments of petroleum and hazardous substances in the Gulf area.

Incineration itself is the major release point in both systems. The study estimates total releases of organics and metals for the PCB wastes is 22.5 metric tons per year for both systems if one includes both stack releases and scrubber effluent. Under the assumptions of this case study, metals account for the largest portion of the releases.

Effects from Incinerator Releases: The study estimated and compared possible human health and environmental effects due to incinerator releases and fugitive releases from transfer and storage equipment.

The analysis of human health risks estimates the incremental risk of developing cancer for a hypothetical "most exposed individual" (MEI) who resides at the location of the highest overall risk due to air concentrations resulting from incinerator stack and transfer/storage fugitive releases. For the land-based systems, the location of the MEI is assumed to reside at that point on the coast where modeled concentrations are highest averaged over a year. These risk estimates assume 70 years of continuous exposure. Table 4–3 presents the incremental risk of developing cancer for the most exposed individual due to releases from land- and ocean-based fugitive (transfer/storage) and stack releases. As shown, the incremental risks from land-based incineration releases are about 3 chances in 100,000 for the locations and wastes considered. Virtually all of the incremental risk to MEI are due to stack releases, with fugitive releases resulting in increased risks of less than 1 in 1 million. Incremental risks to the

TABLE 4-3. SUMMARY OF INCREMENTAL CANCER RISK TO MOST EXPOSED INDIVIDUAL FROM INCINERATOR RELEASES

Ocean-based System*	EDC Waste	PCB Waste
Stack (coastline)	1.06×10^{-6}	6.37×10^{-7}
Fugitives (port)	4.97×10^{-10}	2.02×10^{-8}
Land-based System (average of two sites)		
Stack	3.14×10^{-5}	2.74×10^{-5}
Fugitives	1.69×10^{-8}	7.05×10^{-7}
Total	3.14×10^{-5}	2.81×10^{-5}

*The ocean system is not totalled because the releases are at different locations.

Source: U.S. Environmental Protection Agency

most exposed individual at the coastline for the ocean-based system range from 1 in 1 million to 6 in 10 million. As shown, the risks from fugitives to the MEI near the port facility are less than 2 per 100 million.

The data and methods used to generate these incremental risk estimates are highly uncertain and tend to overestimate expected human health effects. Thus, the absolute risk levels indicated by these figures must be interpreted with caution. However, a comparison of the relative risks indicates that for the PCB waste, land-based emissions create about 40 times more incremental risk to the MEI than do ocean-based emissions. For the EDC waste, the ratio of land to ocean risk is about 30 to 1.

An evaluation of the possible environmental effects of stack releases was conducted for the ocean-based system. These analyses indicated there would be no measurable effect on the marine ecosystem. In fact, background atmospheric flux of PCBs into Gulf waters is two to three orders of magnitude greater than deposition from incineration of PCBs.

Effects from Ocean Transportation Releases: Although the probability of a spill is extremely low, the study characterized possible human health and environmental effects from spills at three sites: Mobile Harbor, over the continental shelf on the path to the burn zone, and in the burn zone itself.

The study examined possible human health effects due to volatilization following the extremely unlikely event of the loss of the entire vessel cargo. If the loss were to occur in the harbor within one kilometer of the city of Mobile, short-term dosages exceeding health Threshold Limit Values would occur for populations directly downwind. Spills in other locations would not be expected to cause human health problems.

EDC spills would have relatively minor effects on the marine ecosystem. These small impacts are the result of this compound's rapid diffusion to low concentration levels and its relatively low toxicity to marine species. In addition, bioconcentration of EDC is not a significant phenomenon.

In contrast, substantial spills of PCBs would have major effects on the marine ecosystem. These effects range from being quite severe in the Bay (substantial reduction in benthic species and large bioconcentration effects on fish and

shrimp) to less severe in the burn zone area. Since PCBs are a persistent compound, such effects would be expected to last a long time. Bioconcentration effects in commercial and recreational species would be of most concern in the Bay and contaminated shelf areas.

Implications of the Study for Regulating Incineration at Sea

The incineration study was published in April 1984. It concluded that:

1. Incineration, whether on land or at sea, is a valuable and environmentally sound treatment option for destroying liquid hazardous waste, particularly when compared to land disposal options now available.
2. There is no clear preference for ocean or land incineration in terms of risks to human health and the environment.
3. Although current commercial and onsite hazardous waste incineration capacity on land is adequate to handle existing demand (except for PCBs), future demand will significantly exceed this capacity as other disposal alternatives are increasingly restricted.
4. Although previous research has verified the destruction capabilities of incinerators, and risk studies have shown minimal impact on health and the environment, a program of continuing research is needed to improve our current knowledge of combustion processes and effects.
5. In order to better address the concerns of citizens regarding incineration, EPA needs to improve its public communication efforts and provide more visible leadership in the area of hazardous waste management.

4. INTERMEDIA COST-EFFECTIVENESS ANALYSIS OF MUNICIPAL SEWAGE SLUDGE REUSE AND DISPOSAL

The Clean Water Act requires municipalities to cleanse their waste waters prior to discharging them into the environment. This cleansing process—waste water treatment—generates sludge that must be used or disposed. Sludge management is an integral consideration in the planning and design of waste water treatment plants and can be the most complex and costly part of waste water management. Municipalities currently generate approximately 6.5 million dry tons of waste water sludge a year, or approximately 56 dry pounds per person per year. Sludge production is expected to double to approximately 13 million dry tons annually by the year 2000 as the population increases, as more municipalities comply with Clean Water Act requirements, and as more sophisticated waste water treatment systems are developed and installed.

There are a number of alternative methods for disposing of municipal sewage sludge, each resulting in different impacts on health and the environment through various media. The five major sludge use/disposal options currently available are: land application (food chain/non-food chain), distribution and marketing of sludge products, landfilling, incineration, and ocean disposal. Municipal sewage sludge also contains over 200 different substances, including

toxic metals, organic chemicals, and pathogenic organisms, such as bacteria, viruses, and parasites capable of persisting in the environment. Concerns over the presence of these substances and their possible impact on human health and the environment require that adequate controls be applied to the various sludge management practices.

Regulatory History

Many federal laws require environmentally sound management of municipal sludge. These include the Clean Water Act (CWA); Clean Air Act (CAA); Resource Conservation and Recovery Act (RCRA); Marine Protection, Research and Sanctuaries Act (MPRSA); Toxic Substances Control Act (TSCA); and the National Environmental Policy Act (NEPA). In response, EPA has developed the following set of regulations:

Coverage	Statutory Authority	Reference
Polychlorinated Biphenyls	TSCA	40 CFR 761
Ocean Dumping	MPRSA	40 CFR 220–228
New Sources of Air Emissions	CAA	40 CFR 60
Mercury	CAA	40 CFR 61
Cadmium, PCBs, Pathogens	RCRA	40 CFR 257
EP Toxicity Procedure	RCRA	40 CFR 261 Appendix II

Because efforts to date have neither provided comprehensive regulatory controls nor always guided local governments toward adequate sludge management planning, EPA is taking a number of steps to improve the process. First, EPA intends to consolidate, where practicable, its various existing sludge management authorities within the broad authorities provided under Section 405 of the Clean Water Act to establish minimum requirements for the control of sludge. These regulations will include coverage of sludge management practices that are not now controlled. The focus of this effort will be in EPA's Office of Water Regulations and Standards. As a guiding principle, EPA's Sludge Policy statement requires a consideration of risks, benefits, and costs of all sludge use and disposal practices on an intermedia basis when formulating and implementing sludge regulations and management programs. However, no methodology existed at the time to evaluate and compare the nationwide cross-media impacts associated with alternative sludge disposal options. In response to this need, EPA's Integrated Environmental Management Division (IEMD) embarked on a major study of human health and environmental risks and costs of the major sludge disposal options.

Structure of IEMD Methodology

The broad intent of the IEMD study is to provide a methodology for evaluating the risks and costs of various sludge disposal options for the Office

of Water (OW) to use in developing national sludge regulations. Future work will concentrate on adapting the methodology for use in making local sludge management decisions. More specifically, the purpose is to identify high-risk areas (e.g., contaminants or disposal practices) and develop a profile of the disposal options that provide cost-effective ways to reduce those risks. These results, along with OW internal efforts, will provide a base from which to structure the regulation writing process. Identifying high-risk disposal options, exposure routes, contaminants, and waste water treatment plant types provides another tool for setting priorities in writing regulations. Identifying cost-effective disposal options establishes the types of disposal practices that regulations should encourage.

The IEMD effort, however, does not provide an estimate of an acceptable contaminant level for a particular sludge disposal alternative. This is the current approach of EPA's OW. OW's approach is based upon establishing a permissable exposure (and risk) level for the individual and then back-calculating to evaluate the concentration of sludge contaminants such that the exposure (and risk) levels are not exceeded. This office may also control sludge by disposal rate limits and management practices.

With this in mind, the following is a brief discussion of the four key components of the IEMD model.

Model Plants: The analysis centers around three model plant sizes, each with one of two types of sludges. The sludge types vary by the industrial contribution to the Publicly Owned Treatment Works (POTW) and, hence, by the quantities of the contaminants. EPA also defined seven types of environments, based on soil and climatological characteristics, where the plants can be found. This results in a matrix of six plant types (three sizes and two sludge types) by seven environments for a combination of 42 cells.

Risk Profiles: The model adopts a very simple approach of estimating changes in the expected number of cases of eight health effects (e.g., carcinogenicity, renal effects) associated with reductions of contaminants in the environment as alternative disposal options are used by POTWs. Initially, EPA estimated concentrations of 23 for four exposure routes: inhalation, ground water, surface water, and ingestion through food, for each of the 42 cells in the matrix discussed above. These concentrations cover the five basic disposal options. Concentrations are combined with estimates of populations exposed and unit risk factors or potency estimates (such as EPA's Cancer Assessment Group's cancer risk estimates) to predict the expected number of cases of a health effect.

Cost: Costs have been estimated for each of the disposal options associated with each of the model plants. These have been broken into operating and maintenance costs and annualized capital costs.

Cost-Effectiveness Analysis: The final step in the model, after risks and costs have been estimated, is to calculate the "cost-efficient frontier" of disposal options. Costs are estimated as the dollar costs to the POTWs of switching from one disposal option to another; effectiveness is measured as the reduction in the expected number of cases of the eight health effects associated with the comparable switching for which costs were estimated.

The IEMD model estimates a national risk number for those POTWs designated for industrial waste water pretreatment. A data base of approximately 1700 POTWs was used, compared with the total 15,000. The 1700, however,

do capture the significant portion of the risk since they include most of the large POTWs and smaller ones with significant industrial flow. We have allocated the 1700 POTWs among the cells in the matrix of 42 model plant types, sludges and environments, at both the national and EPA regional level. Once risks and costs have been estimated for each cell, we can estimate a national or EPA region cost and/or risk number.

Results and Discussion

The IEMD intermedia analysis offers several important findings with relevance to the national status of sludge management and to the future direction and scope of EPA's sludge management program. In addition, the study advocates the use of an array of risk assessment/risk management tools to test various policy scenarios. The study has undergone an internal EPA peer review and is currently being revised to incorporate the panel's suggested changes. The revised report is scheduled for delivery November 1985, thus the results discussed below are tentative and subject to change. The results are also discussed in a qualitative manner to give an indication of the kinds of policy questions one can attempt to answer by using this analytical methodology.

1. *There clearly are aspects of sludge management that present very little risk, and conversely there are aspects for which relatively large gains could be expected from focused regulatory activity.*

EPA's programmatic strategy will be more efficient and productive if it is focused on an appropriate subset of disposal options (exposure routes), contaminants, and perhaps size-type mixtures of POTWs. The IEMD model allows the decision-maker to look at both aggregate population risk and maximum individual risk to help focus the regulatory strategy. For example, the *draft* IEMD study, which again concentrated primarily on human health impacts, suggested that relatively large gains could be made by focusing regulatory efforts on two disposal options—crop and pasture application—and on a few heavy metal contaminants. (Note that the distribution and marketing of sludge, especially for home garden use, was not analyzed in the draft study, but will be incorporated in the revised package.) This also points to the fundamental difference between this approach, which calculates aggregate population risk along with maximum individual risk, in contrast to OW's approach which focuses primarily on the latter.

2. *Compared to the current mixture of disposal practices, some options may be viewed as "better" (lower cost/lower risk), while others may be viewed as "worse" (modest cost reduction/risk increase).*

The tentative study results suggested that a total shift among all POTWs from the current mixture of practices to either land application, landfilling, half crop application/half landfilling would reduce costs and risks. Conversely, a complete shift to pasture application would reduce costs by less than 15 percent while increasing risk. The risk portion of the findings could, however, change dramatically after this report is revised.

These findings, although tentative, do illustrate the importance of disposal option selection and the benefits of a rational, systematic approach to it. They also illustrate that perhaps the prevailing Congressional and EPA policy preference for beneficial uses of sludge in some cases point in the direction of higher risks and only marginal cost reductions.

3. *With some refinements and the use of site-specific data, the model can be used as an effective decision-making tool at the regional or local level to assist in the rational selection of disposal options.*

Sludge management involves significant variations in site-specific factors affecting contamination, costs, transport of pollutants, and exposure of human populations. These variations inevitably play a major role in selecting the most appropriate disposal options and techniques—one of the principal factors affecting costs and risks.

Congressional and EPA policies favor, indeed require, that disposal options be selected by local authorities so that these variations may be taken into account. However, the analytical tools necessary to assess systematically site-specific factors in comparing the costs and benefits of local options have not been fully developed and made available to local decision-makers.

The IEMD model will eventually be capable of filling this void and serving as an actual tool for making site-specific decisions. The model will be adapted in order to load data applicable to a particular POTW (e.g., contamination, climatic and soil data, ground and surface water characteristics, proximity of human populations) and be used to generate estimates of costs, risks, and cost-effectiveness for an array of disposal options or mixtures of options.

In sum, then, the IEMD model is a way to put together a number of risk assessment and risk management tools. The model will not provide "the answer," since it is only as good as the information available. The model will, however, provide the decision maker with some indication of policy preferences given the assumptions one makes. For example, if the decision maker has a preference for beneficial reuse of sludge and a preference for not disposing of sludge in the ocean, this model can still be used, but is much more limited in terms of objectively evaluating available options. Alternatively, this approach does provide the more flexible decision maker with a relatively objective means of weighing equally all disposal alternatives. Finally, the model utilizes the risk assessment/risk management tools of aggregate population risk, maximum individual risk, and cost-effectivesness analysis in an integrated multimedia framework to contribute to more rational decisions at the national and eventually at the local level.

PART II: LAND AND NATURAL RESOURCES

Chapter 5
The Land and Its Uses

Of the nation's nearly 2.3 billion acres of land, over two-thirds is owned by nonfederal entities — private individuals, corporations, nonprofit groups, cities, states, and municipalities. The federally owned "public lands" in the United States — some 730 million acres — encompass a diversity of types and uses — from deserts to forests to tundra, from areas valued for their cultural heritage or that provide important fish and wildlife habitats, to those that are rich in minerals and fossil fuels.

Some of the lands owned by the federal government are designated for special recreational purposes, or are managed to safeguard natural wonders and vistas and to shelter wildlife. A far greater proportion of the federal lands supports multiple uses, including developing and managing natural resources, while supporting recreational activities and ensuring that wildlife habitats are protected.

The last 20 years has seen a rapid expansion of federal lands designated for particular uses, particularly in the National Park System. This has created recent concern about the effect that this expansion and the corresponding rapid growth in recreational demand may have had on maintenance of existing facilities. Thus new approaches to better management of existing facilities and more foresight in planning acquisitions are being applied. There is also evident an increased involvement of the private sector — individuals, nonprofit groups, and corporations — in volunteer programs, in donating important land parcels, and in contributing to maintenance or rehabilitation programs. In addition, in the management of the public lands, there is a recognition that those who use the federal lands and facilities derive a greater benefit than those who do not, and consequently these users, through fees, should contribute directly to some of the costs of maintaining the facilities.

The nation's vast private landholdings are primarily of concern in two areas: wetlands and agricultural lands. Conversions of ecologically important wetlands to other uses, principally agricultural uses, are sometimes encouraged by federal and state programs that contradict policies encouraging their conservation. Some of these incentives and subsidies can be removed, with greater benefit to the preservation of wetlands and without undue negative effects to the agricultural sector.

About 420 million acres of nonfederal land are used as cropland in the U.S. Although this area had been decreasing, for the past few years the cropland acreage has remained fairly constant. Urban encroachment on valuable croplands has been a concern. However, data show that over 80 percent of U.S. cropland lies in rural areas that are likely to be unaffected by urban sprawl, although the problem still does continue in the northeast part of the country.

Agricultural land uses are becoming an environmental concern also because they are the principal source of nonpoint pollution of water through sediments, dissolved salts, pesticides, and nutrients that are transported to both surface water and ground water by rain, irrigation runoff, or infiltration. Soil erosion,

too, especially in fragile land areas, is being given increased attention through research and conservation programs in cooperation with local and state agencies.

The Public Lands: Specially Protected Federal Lands

NATIONAL PARK SYSTEM

In keeping with more than a century of national consensus, this Administration is committed to policies that protect park resources while providing for their use and enjoyment by the public.

Years ago, the National Park System was composed chiefly of large and scenic nature-based national parks, such as Yellowstone, Yosemite, and Grand Canyon, which were created out of existing federal lands in the West. Today's 337-unit National Park System is dominated numerically by culture-based areas, such as national historic sites and national battlefields. Many units are now found in or near urban areas and are primarily east of the Mississippi River. Many, especially those added over the last 20 years, were created from privately owned lands. Indeed, since the establishment of the Land and Water Conservation Fund (LWCF) in 1965, to provide federal monies for park land acquisition, 128 areas have been added to the System. Two billion dollars have been spent since then to acquire private lands, and billions more would be needed to buy the remaining nonfederal parcels within present park boundaries.

This rapid expansion has been controversial. Not only have individuals sometimes been reluctant to have the federal government acquire their land, but also, many of the units were added over the objections of those concerned about establishing new units that lacked true national significance. Existing parks were adversely impacted by this rapid growth as appropriations proved insufficient to expand the system, while simultaneously maintaining existing facilities. By 1980 deterioration of park infrastructure and visitor facilities led the General Accounting Office to conclude that existing conditions in many parks posed health and safety hazards to the public.[1]

System Enhancement Strategies

To protect and enhance park values in a climate of federal fiscal restraint, new approaches are being sought to conserve our parks and provide for their use. The Administration's policies emphasize protection of existing parks, more effective park management, and increased cooperation with state, local, and private entities to meet the challenges now facing the System. These broad policies are reflected in specific strategies to enhance and maintain the National Park System.

Land Protection Plans to Guide Acquisition

To improve management efficiency in the use of LWCF land acquisition funds, the Department of the Interior adopted a new land protection planning process in 1982. Land Protection Plans were to be prepared for 184 units of the System containing nonfederal land. By the end of 1984 plans for 126 units were completed.

These plans identify those parcels in which acquisition of a federal interest is necessary to meet the public purpose established for the unit. The plans also assign priorities to such parcels to guide the National Park Service's purchase plans. To be sure that funds are allocated in the most cost-effective manner, the plans identify the extent of federal control necessary. In many cases easements and cooperative agreements provide less expensive alternatives than traditional fee-simple title purchase, while still allowing NPS to meet fully its resource protection objectives.

When it is necessary for the Government to acquire fee-simple title, consideration is first given to exchanges or donations where appropriate. However, purchase may be required to conserve resources properly or to allow for public use. During 1984, $109.8 millon was obligated to purchase nearly 24,000 acres of land in some 30 units of the System. Those units in which significant expenditures were made include: the Appalachian Scenic Trail ($14 million); Sleeping Bear Dunes National Recreation Area ($10.5 million); Golden Gate National Recreation Area ($8.5 million); Santa Monica Mountains National Recreation Area ($2.9 million); and Olympic National Park ($1.7 million).

The government has the authority to condemn land where negotiations to purchase fail. However, such an action is initiated only as a last resort and then only when acquisition is essential to meet responsibilities set out in legislation.

States occasionally donate lands to the National Park System. For example, in 1984 the State of New York donated 125 acres of state-owned land within the Fire Island National Seashore, giving federal protection to an environmentally sensitive area and adding important land to the Seashore. And, although not strictly an "exchange," the Department of the Interior in 1984 was directed by P.L. 98–269 to convey a 282–acre portion of the former Montauk Air Force Station to the State of New York for use as a recreation area.

Park Restoration and Improvement

Partly in response to the 1980 General Accounting Office report concerning health and safety threats to park visitors, the Department of the Interior embarked on a five-year, $1 billion Park Restoration and Improvement Program (PRIP) to rehabilitate physical facilities in the parks. For FY 1985, Congress appropriated $318 million for this program, which will allow its completion one year ahead of schedule.

Yellowstone—America's first National Park, established in 1872—was one of the chief beneficiaries of PRIP. In 1979, the Park Service acquired numerous buildings within Yellowstone, which were previously owned by a concessionaire. These buildings needed to be brought into compliance with existing codes and new federal standards. At the conclusion of PRIP all water and sewer systems in Yellowstone will comply with current standards; all overnight accommodations will meet modern codes or their equivalents; and every major kitchen in the park will have been rehabilitated and will meet present-day sanitation standards. This program has made a dramatic difference. Water and sewer systems, and roads and bridges have been substantially upgraded. Further, this effort has protected park resources from pollution and added to the public's enjoyment of the parks.

To avoid the necessity for major remedial programs in the future, the Park

Service is developing a maintenance management system that should be operational by 1986. It will allow more efficient and effective use of financial and staff resources to maintain park infrastructure. It will do so by inventorying facilities—roads, bridges, buildings, utility systems—then identifying and sequencing their maintenance and rehabilitation needs. This in turn will allow managers to schedule better, and to coordinate their maintenance operations, and generally to make more informed judgments in this critical management area.

Adjacent Land Uses

To protect park resources from activities occurring on surrounding lands, the National Park Service relies heavily on cooperation. For example, NPS is working with the Environmental Protection Agency, the State of Kentucky, and local authorities to resolve local water pollution problems that may impair the Mammoth Cave National Park resource. The Park Service and the Fish and Wildlife Service have recently secured an agreement with the Federal Aviation Administration to deal with the problems caused by aircraft overflights of park and refuge areas. And, NPS and the Bureau of Reclamation are cooperating in studies examining the impacts on riverine resources in Grand Canyon National Park of water releases from the Glen Canyon Dam. However, not every adverse resource impact originating outside park boundaries can be prevented by park management—visibility impairment caused by air pollutants from distant urban areas, for example—but consultation and coordination can avoid or mitigate many such problems.

Special Management Initiatives

Volunteers and Donations

The Administration has sought to increase private sector involvement in managing the National Parks. A successful example has been the nationwide campaign on behalf of the Statue of Liberty, which had its best year in 1984. At year's end, $132 million in donations and pledges had been received toward a total goal of $230 million for the restoration of the Statue of Liberty and nearby Ellis Island. Contributions have come from such diverse sources as large and small corporations, civic organizations, and school children. Work on the restoration began during 1984 and is scheduled for completion in 1986.

All donations to the parks are encouraged, regardless of their scale. So it is that individuals and firms regularly donate artifacts, equipment, materials, and many other items when a park seeks public involvement. At many parks such involvement has been formalized with the publication of a "gift" catalogue listing items whose donation would contribute to a better park. It may include tangible items as well as services that attract individuals willing to contribute their talents to conduct research, for example, or to organize a library's holdings or to help in the interpretation of the park's resources. There are also very special donations, such as the $7 million privately funded Viet Nam Veteran's Memorial, which President Reagan accepted on Veteran's Day in 1984 on behalf of the American people.

This kind of voluntarism has long been a hallmark of the American people. The number of participants in the Volunteers-in-the-Parks Program has increased

dramatically during the last four years—from just over 8,000 in 1981 to more than 26,000 in 1984. This exceptional public willingness to aid directly in the operation of our National Parks is a measure of our commitment to the national park idea and the esteem in which the parks are held.

Tax Incentives

A major influence on private contributions is the incentive program for the rehabilitation of historic structures. Congressional passage of the Economic Recovery Tax Act in 1981 provided tax advantages for the investment of private capital in the repair and refurbishment of historic properties. The NPS reviews projects to ensure they meet the Act's requirements. Almost 10,000 projects nationwide have qualified for these incentives, representing $6.25 billion in rehabilitation work. Of these, more than 3,200 projects accounting for $2.1 billion in private sector investment were approved in 1984.

User Fees

Fees are collected from visitors at 114 of the 337 units in the National Park System. In accordance with existing law, only 60 units have entrance fees. For most such areas, there has been no increase during the last 15 years, and in some parks current entrance charges are less than they were 65 years ago. Recreation use fees—for campgrounds, boat launching, cave tours, and the like—are collected at some 79 units. During FY 1984 over $21 million was obtained from the visiting public from charges of all kinds. These monies were placed into the Land and Water Conservation Fund. The Administration has proposed removing existing statutory limits on entrance and use fees and earmarking these funds for the Park Service operations.

NATIONAL WILDLIFE REFUGE SYSTEM

The National Wildlife Refuge System is comprised of 427 units totalling more than 90 million acres. Every major North American life zone is represented within the System, from Arctic tundra to tropical rain forest, from riparian hardwoods to desert islands. Yet for all its diversity, the System continues to acquire important habitat, especially those that will protect threatened plant and animal communities.

System Enhancement Strategies

Acquisitions

The Fish and Wildlife Service (FWS) has pursued a land acquisition policy based on the "willing seller" concept. First, the most efficient and appropriate method to protect a parcel of land is determined. For example, the FWS explores local measures such as county or city zoning ordinances that could be employed to protect a tract of land, or it seeks out cooperative agreements with landowners and private companies to protect habitat and examines less-than-fee alternatives, such as easements or leases. When actual purchase is necessary, willing sellers are always sought out first; only as a final choice is condemnation considered. During 1984 the FWS acquired via purchase three new additions

to the National Wildlife Refuge System: Ash Meadows, Nevada, at 11,173 acres; Sandy Point in the Virgin Islands, 327 acres; and Currituck, North Carolina, 512 acres.

Additions to the National Wildlife Refuge System are also made through transfers of land from other agencies of the federal government. Sometimes lands are exchanged, or the Service can declare a "pauper's oath" and acquire land from other willing federal agencies without obligation, because the value to the resource is significant but Service funds are not available. In 1984 the 174-acre Cape Charles National Wildlife Refuge in Virginia was created via transfer from the Department of Defense.

The National Park Service is allowed to accept land donations for the National Wildlife Refuge System, but the lands must be worthwhile and of benefit to the System. Alligator River National Wildlife Refuge in North Carolina was a 120,000-acre donation from the Prudential Insurance Company, and Pierce Ranch in Washington was a 312-acre gift to the System in 1984. The Service also has the option to sell donated tracts or exchange them for more suitable habitat areas. It exchanged lands to improve management of the American Crocodile National Wildlife Refuge in Florida, through cooperation with the Trust for Public Lands.

The Service also receives lands from nonprofit organizations, such as The Nature Conservancy and the Trust for Public Lands, for inclusion in the refuge system. In 1984 The Nature Conservancy donated lands, including Chimon Island, for creation of the new Connecticut Coastal National Wildlife Refuge. The Trust for Public Lands donated tracts to Key Deer National Wildlife Refuge in Florida and to Big Boggy National Wildlife Refuge in Texas.

Accelerated Refuge Maintenance Management

In a system of lands and facilities as diverse and widespread as the national wildlife refuges, maintenance and good management are of great importance—in fact, they are essential to safeguarding the very habitat conditions created to attract and shelter wildlife. The Accelerated Refuge Maintenance Management program was an Administration initiative approved by Congress to increase funding for effectively maintaining such refuge facilities as water control devices, bridges, roads, visitor contact stations, and similar structures. In 1984—the program's first full year of funding—approximately $15 million was applied to this nationwide effort, with more than $17 million scheduled for 1985 efforts.

In 1984 the Service also developed and tested a Maintenance Management System at selected field stations; the new system was designed to aid long-term improvement of the refuge's maintenance system and began field use in 1985.

Adjacent Land Uses

The Service often enters into cooperative agreements with adjacent landowners to help protect both the refuge's resources and neighboring lands. Frequently, both parties will be involved in refuge planning and in other local planning efforts. The Lower Rio Grande Valley Task Force in New Mexico provides a good example of a cooperative effort involving the Service, state, private, and nonprofit interests working together for the benefit of the Bosque del Apache National Wildlife Refuge and the environment of the Lower Rio Grande Valley.

Special Management Issues

Resource Protection

During 1983, the Service published a report identifying resource problems on all field stations, including national wildlife refuges, fish hatcheries, and research facilities. The report identified land use, public use, water management, operational, and other problems that are causing or have the potential to cause significant damage to natural resources, physical facilities, or visitor experience. In 1984, $5 million for resource management and $3 million for construction were dedicated to address these specific resource problems.

User Fees

User fees are presently collected for such recreational refuge activities as camping, tours, hunting, swimming, reservations, etc. These fees are collected under authority of the Land and Water Conservation Act and all such proceeds go to the U.S. Treasury. In 1984 the Service collected $136,000 in such fees. Economic use fees are derived from activities such as timber harvest, grazing, water sales, or mineral extraction (when such activities are compatible with other refuge uses). Proceeds from these activities, under authority of the Migratory Bird Conservation Act (MBCA), go to the Refuge Revenue Sharing Fund (RRSF) for payments to counties.

The Public Lands: Multiple Use Resource Lands

BUREAU OF LAND MANAGEMENT

The Bureau of Land Management (BLM) is responsible for carrying out a full range of programs for the conservation, development, and management of both surface and mineral resources on approximately 300 million acres of public lands located primarily in the western United States, including 96 million acres in Alaska. This public estate constitutes more than 12 percent of the total land surface of the United States. In addition, BLM administers mineral leasing and supervises mineral operations on 370 million acres of subsurface mineral estate underlying other federally administered, state, or private ownerships throughout the United States, and supervises most mineral operations on Indian lands.

The Bureau's primary objective is to manage the public lands and their resources under the concept of multiple-use. Renewable resources are managed to recognize the nation's needs for domestic sources of food, fiber, timber and wildlife on a sustained yield basis and to make significant contributions to national, regional, and local economies that depend upon them. Mineral resources are managed to provide a secure domestic source of energy and strategically important nonenergy minerals, to ensure orderly and timely development, and to obtain fair market value return to the federal government. (BLM'S management of the federal mineral estate is discussed in Chapter 8 — Energy and Minerals for National Security and Prosperity.)

The public lands also provide many opportunities for human use and enjoyment through recreational, ecological, scientific, and other nonconsumptive

activities. BLM manages the public lands with these interests in mind, as well as with a concern for environmental protection, service to the public, and opportunity for public involvement in the development of BLM plans, managerial considerations, and regulations.

Volunteers and Contributed Services

BLM's programs benefit substantially from the services of volunteers and other supplemental workers. Some 3,500 volunteers contributed approximately 150 work-years of service, valued at $1.9 million, during the year. This has had the effect of extending the agency's work force by about 1.5 percent. At the same time, these volunteers are furthering their educational goals and improving skills through on-the-job training, while obtaining personal satisfaction through service to the public.

The volunteer program is expected to benefit further from legislation passed at the end of 1984 authorizing BLM to pay for certain costs related to acceptance of contributed services, including reimbursement to volunteers for such out-of-pocket costs as mileage or meals.

In addition to volunteer services contributed by individuals and organizations, BLM is attracting significant private sector donations of funds, equipment, and materials to assist in its land management activities.

Wilderness, Recreation, and Cultural Values in BLM Lands

Wilderness Review

Preservation and management of wilderness became part of BLM's multiple use mandate with the passage of the Federal Land Policy and Management Act of 1976. The first phase of the wilderness review process was an inventory of all BLM lands for wilderness characteristics, completed in November 1980. BLM is now studying approximately 780 wilderness study areas (WSAs) containing about 24 million acres.

During 1984, BLM passed the halfway mark in completing these field studies. Recommendations from 34 field level wilderness study efforts, covering a total of 202 WSAs, were under review in Washington in preparation for action by the Secretary of the Interior.

BLM continued its monitoring of WSAs to protect them against unauthorized activities that could impair their suitability for wilderness designation. Where violations were encountered, BLM sought to have the responsible parties rehabilitate the damaged lands. Such rehabilitation work is in progress in a number of these areas.

Five "instant study areas"—areas that had been formally identified prior to July 1, 1975, as natural or primitive areas—were designated as wilderness by Congress during 1984. These were Aravaipa Canyon (Arizona), Paria Canyon (Arizona and Utah), Paiute (Arizona), Vermillion Cliffs (Arizona), and Bear Trap Canyon (Montana). Final wilderness environmental impact statements (EISs) were issued on four other "instant study areas"—Great Rift (Idaho), Powderhorn (Colorado), Humbug Spires (Montana), and Scab Creek (Wyoming)—leading to Secretarial recommendation to the President.

Congressional action also added 13 other BLM areas in Arizona, California,

Oregon, Washington, and Utah to the National Wilderness Preservation System. As a result of these additions, the total acreage of BLM public lands in the wilderness system increased from approximately 13,000 acres at the beginning of the fiscal year to 341,000 acres at the end.

BLM's first wilderness management plan was published in draft form during 1984 for the Bear Trap unit of the Lee Metcalf Wilderness in Montana.

Recreation Management

Hiking, camping, hunting, fishing, river rafting, off-road vehicle use, and other resource dependent recreation are some of the most popular uses of the public lands. An estimated 56 million visits to public land recreational areas were made during 1984. BLM's recreation program provides information on available recreation resources, input to Bureau planning efforts where recreation issues exist, and visitor assistance, use supervision, and Recreation Area Management Planning in more intensively used areas.

In February 1984 a special recreation permit policy was adopted. It required all commercial and competitive users and, in special areas, groups and individual users to obtain permits and pay fees for recreation use. Regulations for special recreation permits were revised to reflect the new policy and published in August 1984. During 1984, nearly 6,000 special recreation permits were issued. Fees collected for these permits exceeded $650,000.

A number of long-term visitor areas have been designated along the Lower Colorado River in Arizona and California. Minimal facilities are provided, and, as of October 1, 1984, a nominal fee of $25 per season is charged for issuing a special use permit. These designated areas will help control indiscriminate use of the public lands and minimize damage to the natural resources.

Nineteen cooperative management agreements covering protection of historic resources, snowmobile trail management, management of an off-road vehicle area, and cave resource management have been executed with user groups, conservation organizations, universities, and state and local governments.

Cultural Resource Management

Public lands contain a physical record of some 20,000 years of human history. In a partial inventory, BLM has recorded approximately 100,000 archaeological and historical properties and estimates that as many as 5 million properties exist on public lands.

In its cultural resource management program, BLM identifies records, evaluates, plans for, and makes informed judgments on the use of the cultural resources under its jurisdiction. Approximately 17,000 cultural properties have been evaluated and classified according to several categories of use: socio-cultural use, current or potential scientific use, management use, and conservation for future use.

More than 35,000 fragile and threatened cultural properties were protected during the year by one or more means, including patrolling, posting signs, erecting fences, and site stabilization; periodic patrols were made on nearly 2.5 million acres of public lands.

Areas of Critical Environmental Concern (ACECs)

The Federal Land Policy and Management Act of 1976 defines areas of critical

environmental concern (ACECs) as areas "within the public lands where special management attention is required (when such areas are developed or used, or where development is required) to protect and prevent irreparable damage to important historic, cultural, or scenic values, fish and wildlife resources or other natural systems or processes, or to protect life and safety from natural hazards."

The identification, designation, and management of ACECs is an integral part of BLM's multiple use planning and management processes. After designation, an individually tailored management plan for each area is developed.

Approximately 1,346,070 acres of public lands in 181 areas have been designated as ACECs; 95 percent of these were designated within the past four years. Seventy-five of these areas, containing about 583,443 acres, are found in the California Desert Conservation Area.

Managing and Using the Public Resource Lands

Rangeland Management/Cooperative Management Agreements

Public rangelands—lands on which the native vegetation is predominantly grasses, grasslike plants, forbs, or shrubs — cover 170 million acres in 16 Western states, exclusive of Alaska. BLM's management of these lands is guided by the Taylor Grazing Act (TGA) of 1934, the Federal Land Policy and Management Act (FLPMA) of 1976, and the Public Rangelands Improvement Act (PRIA) of 1978.

In 1984 the rangeland management program celebrated the 50th anniversary of passage of the Taylor Grazing Act, which was signed into law by President Franklin D. Roosevelt on June 28, 1934. Program emphasis continues to be on goals established by the TGA as modified and expanded by FLPMA and PRIA:

- To administer livestock grazing on public rangelands to balance use and sustain resource productivity;
- To protect and improve the rangeland resources through sound land use planning, which includes making cost effective investment and management decisions;
- To make decisions in consultation, cooperation, and coordination with the lessees/permittees involved, the affected landowners, interest groups, individuals, and other agencies; and
- To make sure that improvements in rangelands provide multiple use benefits.

BLM conducts soil and vegetation inventories to aid the land use planning process and to provide a baseline for monitoring. Monitoring studies are conducted to determine if rangeland management goals are being met and to determine the need for and extent of changes from current management practices. Grazing permits are issued for periods of up to 10 years to authorize grazing use by approximately 21,000 livestock operators.

Most range managers generally agree that the condition of the public rangelands has substantially improved during the past 50 years. This improvement is partly the result of a decrease in livestock numbers from the excessive numbers using public rangelands prior to passage of the Taylor Grazing Act of 1934. Additionally, the improvement in rangeland condition can be attributed to conservation and development measures, better livestock management practices, and cooperative efforts by BLM, livestock operators, and other rangeland users.

Preparation of site-specific grazing environmental impact statements (EISs) continues. The 99 completed EISs, including 15 completed in fiscal year 1984, address livestock grazing on 125 million acres of public lands in 10 states; an additional 20 EISs covering 20 million acres will be completed in fiscal year 1985.

Baseline soil and vegetation inventories conducted in connection with these EISs have provided a basis for new estimates of range condition. Current condition classes are based on the kinds and proportions of existing plants compared to the potential plant communities for all ecological sites. The resulting ratings indicate that 5 percent of BLM rangelands are in excellent condition, 31 percent are in good condition, 42 percent are in fair condition, and 18 percent are in poor condition. Although methods of rating have varied over the past 50 years, these ratings illustrate a gradual and steady improvement in range conditions.

BLM Rangelands
Percent by Condition Class

Year	Excellent	Good	Fair	Poor
1936	1.5	14.3	47.9	36.3
1966	2.2	16.7	51.6	29.5
1975	2.0	15.0	50.0	33.0
1984	5.0	31.0	42.0	18.0

These figures do not reveal all the progress that has been made. Ecological condition classes only describe the condition of the vegetation in relation to the potential natural vegetation for that site. These classes do not necessarily indicate how well the current vegetation meets management objectives for a site. BLM is developing a resource value rating system that will express rangeland condition in relation to the multiple-use management system.

Improving the condition of public rangelands for the benefit of wildlife, watershed protection, and domestic livestock is a primary concern of the range program. Range improvement activities include seeding, fence construction, weed control, water development, enchancement of fish and wildlife habitat, and maintenance of existing improvements.

BLM is completing the transfer of responsibility for maintaining structural rangeland improvements to individuals directly benefiting from those improvements. Funds formerly spent for maintenance will be available for new improvements. In another effort to increase the amount of funds available, BLM is encouraging private contributions toward rangeland improvements on public lands.

During fiscal year 1984, the following range improvement activities were completed: 652 water facilities were developed; 519 miles of fencing were constructed; 133 management facilities were developed; 13,026 acres of vegetation were treated; 730 range improvement projects were surveyed and designed; 1,304 water facilities were maintained; 321 miles of fencing were maintained; and 107 management facilities were maintained.

BLM and the U.S. Forest Service continue to conduct the experimental stewardship program (ESP) authorized by PRIA. The purpose of ESP is to explore

ways to improve the public rangelands through increased cooperation among all rangeland users involved by providing incentives for or rewards to livestock operators whose grazing management results in improved resource conditions.

Based on the results of ESP and similar cooperative management efforts with state wildlife agencies and volunteer groups, BLM has initiated a cooperative management agreement (CMA) program. BLM will enter into CMAs with livestock operators, wildlife and recreational organizations, and other user groups for shared management of a specific activity on a specific area of public land.

During the year, 27 CMAs were signed with livestock operators following an evaluation of each operator's qualifications, including his past record as a responsible and effective rangeland resource manager. A CMA does not give a cooperator the authority to limit or exclude other public land uses and users, nor does it exempt a cooperator from laws or regulations affecting public land management. It does recognize those demonstrating a commitment to a high level of stewardship.

Soil, Water, and Air Resources Management

Protection and management of the soil, water, and air resources of the public lands are basic BLM responsibilities and are central to both the short- and long-term objectives of BLM programs. Identification or inventory of existing soil, water, and air resources provides the information needed for multiple-use planning and program management.

Assessing the impacts of other resource programs and uses on soil, water, and air resources and establishing protective measures are significant program efforts. BLM also develops practices and measures to stabilize soils and improve water quality and quantity. During fiscal year 1984, 340 watershed improvement projects were developed.

A total of 7.5 million acres of soils were inventoried during the year, bringing the total number of acres inventoried to 127.3 million acres. The goal is to identify the characteristics of the soils on all public lands by 1990. Information on the acreage inventoried is used for planning by other resource programs.

With the hydrologic inventory of 2.9 million acres and the inventory of 9,808 water sources in fiscal year 1984, almost 50 percent of the total workload necessary to identify and quantify water use is now complete. BLM will share this information with states to help them identify which water sources on public lands are available for appropriation under state water law. Filings were made to the states on 7,156 water sources by BLM to protect water needed for management of the public lands.

BLM's air resource program supports the National Acid Precipitation Assessment Program by operating 11 acid rain monitoring stations at remote locations in the western states. These stations are providing data essential for the development of national acid precipitation maps to determine the trends and possible impacts of acid deposition in the western United States. In addition, 55 air/climate monitoring stations are being maintained.

Wild Horse and Burro Management

More than 60,000 wild horses and burros roaming public lands in 10 western states are under the jurisdiction of BLM. The wild horse and burro program's objectives are:

- To preserve wild free-roaming horses and burros on public lands as symbols of America's historic and pioneer heritage;
- To protect wild free-roaming horses and burros from illegal capture, branding, harassment, or death;
- To manage wild free-roaming horses and burros as components of the public lands in a manner that maintains or improves the rangeland ecosystem; and
- To provide humane care and treatment for wild horses and burros removed from the public lands.

To help alleviate problems of overpopulation of wild horses and burros and attendant deterioration of vegetation that protects the land, the BLM humanely captures excess animals and offers them to individuals who can provide the appropriate level of care. Through this Adopt-a-Horse program, nearly 5,700 animals were "adopted" in Fiscal Year 1984. This is a 14 percent increase in the adoption rate, but the number of animals captured decreased nearly 17 percent. This decrease came from diversion of funds from the removal program to feed the large number of unadopted animals in BLM holding facilities.

Wildlife

BLM manages extensive and diverse habitats for hundreds of wildlife species, including some 80 federally listed threatened and endangered plant and animal species. Working with state wildlife agencies, BLM ensures that wildlife needs are considered in all land-use planning and decision-making.

BLM has executed memoranda of understanding and numerous cooperative agreements with 14 western states and seven states in the East. Under these arrangements the states are responsible for wildlife population management, while BLM is responsible for managing the habitat on public lands.

During fiscal year 1984, BLM inventoried 11.9 million acres of wildlife and fish habitat, focusing on those public lands where critical issues or potential conflicts are the greatest. Ninety-four new habitat management plans were prepared or revised, and BLM participated in the development of 15 recovery plans and the implementation of 25 such plans for threatened and endangered species. Monitoring to evaluate the effectiveness of management actions was performed on 20.7 million acres of habitat.

Wildlife and fish habitat was improved on 2.3 million acres and maintained on 20.7 million acres. BLM continued cooperation with state wildlife agencies to ensure conservation and rehabilitation of wildlife habitat under the Sikes Act and FLPMA authority. Also, BLM entered into 12 new cooperative management agreements for wildlife habitat.

Timber Management on BLM Lands

BLM administers approximately 90 million acres of forest land, of which 64 million acres are in Alaska, where timber development has been deferred until state selection, Native claims, withdrawals, and other dispositions are completed. Of the 25 million acres of forest land outside of Alaska, five million acres are capable of producing high quality commercial timber in quantities sufficient to warrant intensive management. The remaining 21 million acres, called "woodlands," are generally tree covered but in varying degrees of density.

By far the most commercially valuable of the timber lands managed by BLM are the 2.4 million acres in western Oregon known as the "Oregon and California (O&C) railroad grant lands" and the "Coos Bay Wagon Road (CBWR) grant lands." Among the most productive forests in the country, these lands produce about 91 percent of the total board feet harvested annually from BLM forests.

The depressed lumber market and unusually high bidding on timber sales from 1979 to 1981 continued to plague the purchasers of BLM timber. However, timber sale activity remained brisk, and timber harvest was at the highest level since 1979. In western Oregon, 1,006 million board feet of timber were sold during fiscal year 1984, and 1,038 million board feet were harvested. On public lands outside of western Oregon, BLM sold 92 million board feet of timber.

Reforestation was completed on about 17,500 acres in western Oregon and on 700 acres in other areas. In addition, 49,500 acres in western Oregon and 2,200 acres outside of western Oregon were prepared, protected, or otherwise treated for timber management.

Land Exchanges and Transfers

During fiscal year 1984, BLM's Lands Program focused on:

- Responding to state and local government requests for acquisition or use of public lands for community expansion and recreation or public purpose activities;
- Modifying land exchange processing to eliminate unnecessary requirements and streamline procedures;
- Accelerating programs of state and private land exchanges to foster improved and more efficient management of public lands;
- Transferring federal land to states to satisfy state indemnity (in-lieu) land entitlements that remained outstanding; and
- Producing regulations to clarify and simplify land sale procedures.

The Recreation and Public Purposes (R&PP) Act authorizes the federal government to lease or sell public lands at less than full fair market value to state and local governments and nonprofit groups for recreation and public purpose needs. In fiscal year 1984, BLM processed 288 R&PP applications involving 81,443 acres of public land. Applications continue to be filed at a rate of approximately 80 per year.

Land exchanges, that is, exchanging public land for state and private land, provide opportunities to simplify ownership patterns and improve respective management programs, thus meeting both public and private needs. In 1981, 70,578 acres were conveyed through exchange. In 1982, that figure climbed to 95,424 acres, and in 1983 to 134,079 acres. In 1984, 67 exchanges conveyed 439,000 acres of public lands to states and private interests in return for 480,000 acres of their lands. The acreage total represents about a 270 percent increase over that exchanged during fiscal year 1983.

As western states were admitted to the Union, they were granted federal land for a variety of purposes. In many cases, however, land due the states had been preempted by settlement, mining claims, and federal programs. Accordingly, Congress authorized the states to make indemnity or in-lieu selections for the land "lost." Conveyance of such in-lieu land to the western states has been accelerated rapidly. Between 1977 and 1980, only 3,859 acres were transferred.

This increased to 58,825 acres in 1981 alone, 80,281 in 1982, and more than doubled to 185,228 acres in 1983. With much of the work accomplished, 1984 transfers dropped to 30,552 acres. BLM expects essentially to complete entitlement work during fiscal year 1985.

Withdrawal Review

The Federal Land Policy and Management Act mandated a review of certain public land withdrawals in 11 western states by 1991 to determine whether and for how long the existing withdrawals should be continued.

During fiscal year 1984, BLM completed field review of approximately two million acres withdrawn by other agencies from all or some of the mineral and nonmineral public land laws.

The Secretary of the Interior approved 45 public land orders opening 241,000 acres to surface entry, of which 22,500 acres also were opened to mining. No substantial acreage was opened to mineral leasing since the withdrawals did not segregate from this activity. BLM also terminated approximately 6.5 million acres of land classifications.

Federal Land Interchanges: BLM/FS Proposal

An innovative proposal to improve public service, enhance management efficiency, and reduce agency costs was jointly developed during 1984 and announced in early 1985 by the Department of Agriculture's Forest Service and the Department of the Interior's Bureau of Land Management. The concept involves interchange of lands and minerals administered by the two agencies to resolve historical problems of "patchwork" administrative jurisdictions.

In many areas, the public lands administered by BLM and the forest lands administered by the Forest Service are intermingled in small blocks, causing management difficulties and inefficiencies as well as causing the public inconvenience in dealing with two agencies.

Detailed implementation guides developed with extensive public consultations and a legislative proposal for actual transfer of the administration of these lands and minerals by Congress are the next steps in making this important concept a reality.

THE NATIONAL FOREST SYSTEM

The U.S. Forest Service is responsible for national leadership in forestry and directly manages about 10 percent of the nation's total land. This land includes such diverse areas as forests, range and grasslands, alpine areas, lakes, and streams. The management and protection of National Forest System land under the multiple-use concept enhances the utility and quality of fish and wildlife habitats, outdoor recreation, wilderness, water resources, forage, and timber.

The Forest Service cooperates with the states and territories, local governments, forest products industries, and private landowners to promote good forestry and land stewardship practices on nonfederal forest lands and to increase the efficient use of wood. Most of the technical and financial assistance is provided through state forestry organizations. Assistance is extended for a varied mix of projects such as: controlling tree diseases, insects, and rodent pests; producing improved seedings; reducing soil erosion; planting trees to conserve

energy; reforesting harvested or burned-over lands; improving timber stands; protecting against fire; and developing fish and wildlife habitats.

Wilderness and Recreation: Trends in Quality and Use

Wilderness

The 98th Congress made substantial changes in the National Wilderness Preservation System on National Forest System (NFS) lands. The Wilderness System on these lands increased 6.8 million acres to a total of 32.1 million acres in 327 individual areas. A major portion of the roadless area issue was resolved by this wilderness legislation. Of the 64.7 million-acre roadless inventory, about 16.7 million acres have been designated wilderness. Another 27.7 million acres have been released from further consideration for wilderness during the current round of Forest Service planning. Remaining areas will be studied as part of the Forest Service land management planning process (36 CFR 219) or as separate special studies.

Wild and Scenic Rivers

Of 14 National Forest study rivers recommended for designation and pending before the 98th Congress, four were added to the Wild and Scenic River System: the Tuolumne in California, the Illinois in Oregon, the Au Sable in Michigan, and the Verde in Arizona, with an aggregate length of 196.9 miles. Congress mandated three new studies: the North Fork Umpqua in Oregon, the Horsepasture in North Carolina, and the Wildcat Creek in New Hampshire.

The National Wild and Scenic River System now includes 65 rivers totaling 7,217 miles, of which 2,098 miles are administered by the Forest Service. The Forest Service is evaluating the Wild and Scenic River eligibility of National Forest rivers that are included in the 1982 National Rivers Inventory. Eligible rivers will be studied further for possible recommendation to Congress for inclusion in the system.

Recreation

The National Forests and National Grasslands receive 42 percent of the total visitor days of use that takes place on federal lands. National Forest recreation includes a wide spectrum of activities, ranging from camping at constructed facilities to backpacking in primitive settings. The Forest Service maintains a total of 6,000 campgrounds and picnic grounds, along with another 4,000 sites for such uses as swimming, boating, observation, and interpretation. An additional 3,000 sites, such as ski areas, resorts, and marinas, are operated and maintained by the private sector through special use permits on National Forest System lands.

Recreation use at developed sites and special-use permitted sites totals a little over one-third of recreation use. The remaining two-thirds is within the "dispersed recreation" category, which includes countless primitive facilities, 100,000 miles of maintained trails, and 300,000 miles of roads, in the general forest setting of approximately 191,000,000 acres of National Forest System lands. These statistics demonstrate the continuing popularity of unconfined and unstructured recreation opportunities.

In 1984, 227.6 million recreation visitor days (RVDs) occurred on National Forest Service lands. Of the total use, 10.2 million RVDs occurred in wilderness and primitive areas. The western states, including Alaska, received 78 percent of this use. Use at Forest Service operated facilities—such as campgrounds, picnic areas, and swimming and boating sites—was 82.3 million RVDs in 1984.

Recreation Management and User Fees

As the demand for wilderness and recreation uses of the National Forests increases, so does wear and tear on trails and recreation area facilities. Yet the uses of recreation areas and facilities and the costs of providing them have expanded at a greater rate than has the funding available for maintaining, refurbishing, and improving those areas and facilities, as shown in Figure 5-1. Current economic and budgetary constraints limit the ability of federal land-managing agencies to meet recreation demands. Consequently, some facilities have been closed, while others have shortened seasons. Other burdens associated with increased public access, such as illegal removal of firewood, timber thefts, and vandalism at archaeological sites, have diverted greater management attention to law enforcement. Trash collection is also an increasing problem.

The Administration believes that the National Forest System should be available for all Americans. Yet those who actually visit the recreation areas and use the facilities derive a greater benefit than these who do not. Thus, the actual beneficiaries—the users of the National Forest recreation facilities—should contribute directly to the costs of maintaining those facilities, especially those higher cost facilities. Additional authority from Congress is necessary to develop a fair and efficient recreation fee program for the National Forests. Consequently, the Department of Agriculture has recommended to Congress that a reasonable fee, to cover at least 25 percent of these costs, be charged to those persons actually taking advantage of recreational opportunities, and that the prohibitions to such a fee system now contained in the Land and Water Conservation Fund Act be deleted. (Currently the Forest Service may charge recreation user fees at approximately 2,300 recreation sites, which has generated fiscal year 1984 revenues of $12 million.) Charges would be equitably based on the costs incurred in providing the various services. The Administration also recommends that volunteers be allowed to serve as collection officers.

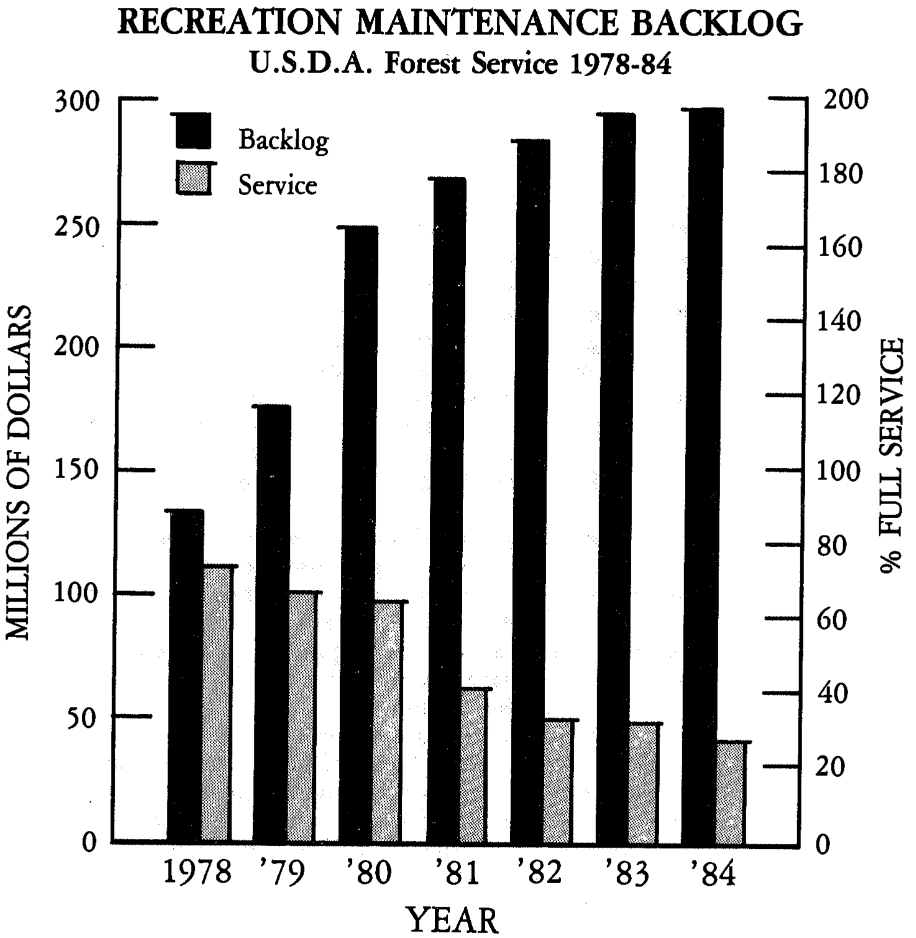
Volunteers Program

The present volunteers program in the National Forest offers individuals from all walks of life the opportunity to donate their services to help manage natural resources. This program continues to grow in popularity as people gain personal satisfaction from helping to carry out natural resource programs.

In 1984, the volunteers program attracted 43,496 participants who contributed 1,784 person-years of work valued at approximately $23.4 million.

The Touch America Project (TAP) is a special volunteer program that gives youths between the ages of 14 and 17 a chance to gain job experience and environmental awareness while working on public lands. Private sector organizations sponsored over 7,000 youths through TAP in 1984.

FIGURE 5-1



SOURCE: U. S. Forest Service.

Management of the Nation's Forest Lands: Review of Federal Programs

Planning Within the Forest Service

Planning within the Forest Service is primarily directed by the Forest and Rangeland Renewable Resources Planning Act of 1974, as amended by the National Forest Management Act of 1976. The planning effort is accomplished at three levels—national, regional, and local.

The National Plan, called the Renewable Resource Program, recommends a level of future outputs and associated costs for all Forest Service programs. The draft 1985 Program was made available for public review from January

through March 1984. The 1985 Program will be finalized in the coming year and will then be transmitted to the Congress by the President.

During 1984, Regional Guides for all nine Forest Service Regions were completed. The Guide is the connecting link between the National Program and the local planning level. The Guides play a dual role, channeling management direction from the national to the local level and management information from the local to the national level.

The local planning effort is most visible with development of Forest Land and Resource Management Plans for each administrative unit of the National Forest System. Forest Plans provide management direction for the National Forests and Grasslands. By the end of 1984, Forest Plans had been completed on 12 of the 123 administrative units.

Wildlife Habitat Improvement

Habitats were improved for wildlife and fish species in public demand, such as deer, elk, wild turkey, waterfowl, salmon, trout, and bass. Special efforts to protect threatened, endangered, and sensitive species included the reintroduction of peregrine falcons in some areas and the development of a cumulative effects model to assess impacts of resource management activities on grizzly bear habitat.

The Forest Service is continuing to make progress toward resolving the wildlife and timber management controversy over the old-growth habitat needs of spotted owls in the Pacific Northwest and red-cockaded woodpeckers in the South. Increased research and better inventory help to solve the problem of providing adequate habitat to maintain and recover these species while still producing a sufficient timber supply.

Road Construction

The National Forests contain about 342,000 miles of roads of all types. In 1984, the Forest Service constructed or reconstructed a total of 7,649 miles of National Forest roads, a decline of 9.1 percent from 1983. Most new roads were built to improve access to timber sale areas but will also be used for recreation access, resource protection, and future sales.

Timber Harvesting

In the past 10 years (1975–1984) substantially more timber has been sold than harvested on National Forest System lands (Figure 5–2). The average annual volume sold during this period was 10.8 billion board feet. The annual average harvested was 9.3 billion board feet. Only in 1977 was more volume harvested than sold.

During the severe market slump of 1980, 1981, and 1982, the volumes harvested from National Forests dropped sharply to a low harvest level of 6.7 billion board feet. This trend has been reversed in the last two years, with the 1984 harvest level rising to the previous high in this 10-year period.

The value of timber sold during 1975–1984 also exceeded the value of timber harvested by a substantial margin. This was especially apparent in 1979, 1980, and 1981 when purchasers bid record amounts for timber, yet harvested lower valued sales in order to operate in a rapidly declining market. This trend

appears to have reversed itself in 1984 when the value harvested exceeded the value sold for the first time in more than 10 years (Figure 5–3).

Reforestation

More than 376,000 acres of National Forest land were reforested in 1984. Backlog reforestation, which Congress required the Forest Service to accomplish by the end of 1985, has been reduced from the original 3.1 million acres to 113,000 acres. The Agency anticipates that all feasible acreage of reforestation backlog will be treated, on schedule, by the end of 1985 (Figure 5–4).

Timber Stand Improvement

Timber Stand Improvement refers to several types of noncommercial stand treatments designed to improve stand growth or quality. The future usable yield of timber stands can be increased from 15 to 25 percent with treatments such as thinning overly dense stands, eliminating competing shrubs or weed trees, or applying fertilizer to stimulate tree growth. As of October 1, 1984, treatment was recommended on 1.5 million acres. Although the necessity for timber stand improvement has been decreasing for 10 years, it is not yet down to a maintenance level (Figure 5–5).

Insects and Diseases

A host of biological agents as well as natural and man-caused events continuously shape forest ecosystems. Resource inventory surveys show that these cause an average annual unsalvaged mortality of 3.9 billion cubic feet of timber. Forest insects and diseases cause about 60 percent of this mortality, which represents almost 20 percent of the nation's annual timber harvest. In addition to outright mortality, insects and diseases cause other significant impacts, including reduced tree growth, timber quality degradation, reduced forest seed production, esthetic degradation, safety hazards in recreation and other high-use areas, and adverse effects on wildlife habitats.

The gypsy moth, southern pine beetle, western spruce budworm, and root diseases are currently of most concern. In 1984, the gypsy moth defoliated 992,655 acres of northeastern hardwood forests and forested communities. Fifteen states now have areas generally infested with gypsy moth. Populations of southern pine beetle, a destructive pest of southern pine forests, generally declined in 1984. However, southern pine beetle outbreaks in Louisiana and Mississippi began to expand. The Texas outbreak continues to expand, with over 4,800 new infestations reported in 1984.

Western spruce budworm defoliation occurred on about 10.6 million acres in 1984. Root diseases are of particular concern because they cause tree mortality, butt rot, and growth loss; they also predispose trees to insect attacks and windthrow. In the West, where present and potential root disease losses are a major management concern, up to 5 percent of once productive forest land in some areas has been lost to timber production from these causes. Root diseases kill more than 230 million cubic feet of western timber annually.

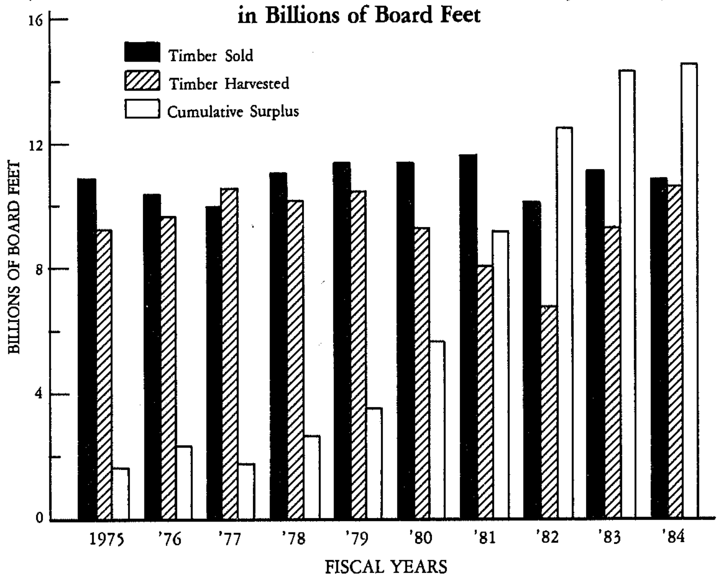
Cooperative Forestry: Federal Assistance for State and Private Forest lands

State and Private Forestry provides technical and financial assistance to states

FIGURE 5-2

NF TIMBER SOLD AND HARVESTED 1975 - 1984

in Billions of Board Feet

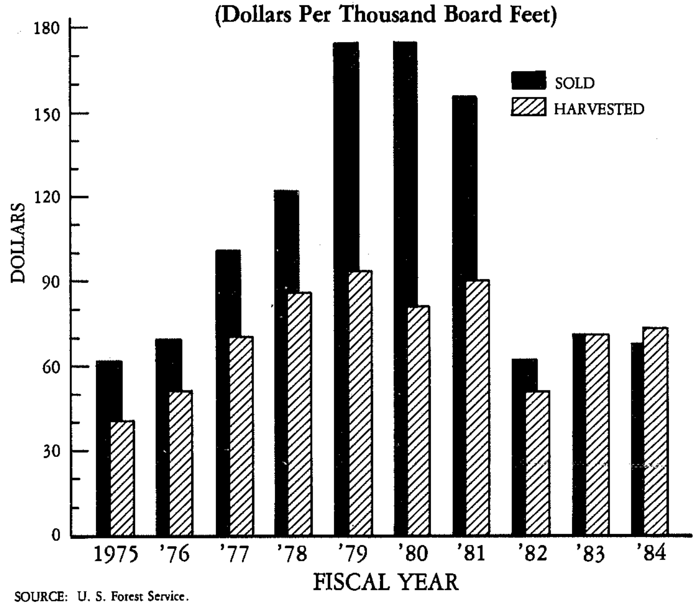


SOURCE: U. S. Forest Service.

FIGURE 5-3

AVERAGE VALUE $ PER MBF - 1975-1984

(Dollars Per Thousand Board Feet)



SOURCE: U. S. Forest Service.

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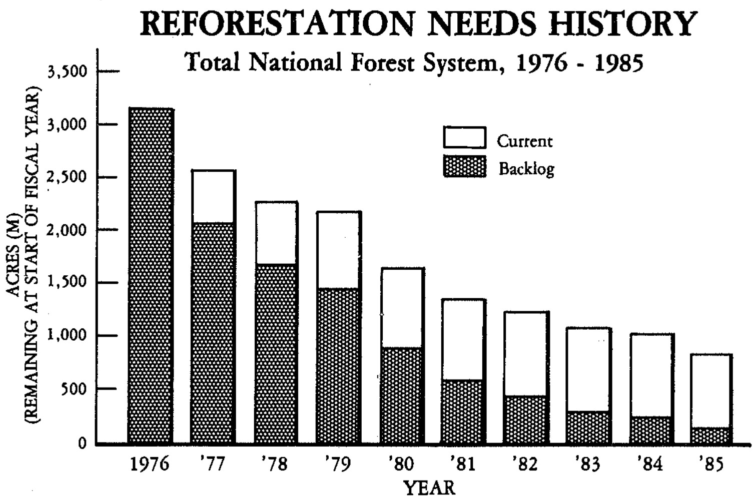
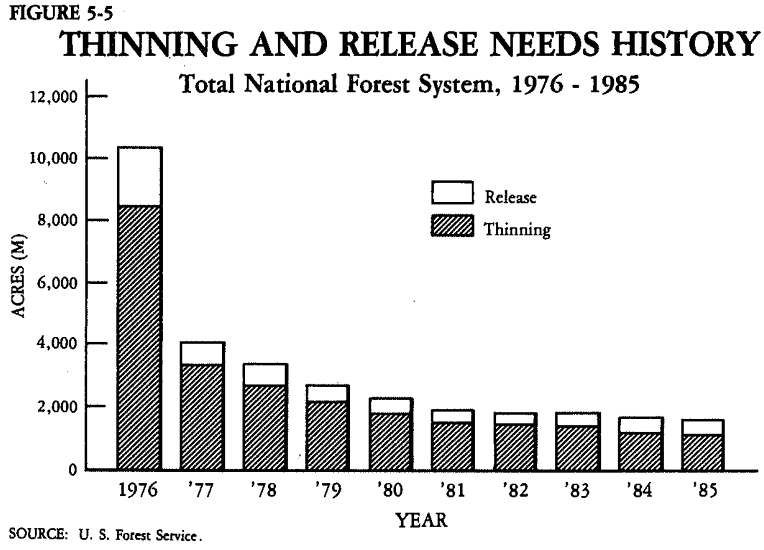
FIGURE 5-4



SOURCE: U. S. Forest Service.

FIGURE 5-5



SOURCE: U. S. Forest Service.

to maximize the social and economic contributions of nonfederal forests and other lands. Principal goals include forest resource management and fire protection on private and nonfederal lands and protection from insects and diseases on all lands. These programs are authorized by the Cooperative Forestry Assistance Act of 1978.

States are responsible for managing, protecting, and planning for nonfederal

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forests and forest operations. The Forest Service assists states in those activities that provide national benefits.

Urban Forestry Assistance

The Urban Forestry program seeks to improve the quality of life through the management of trees, forests, and associated resources in and near urban areas. In 1984, the program helped to reduce the loss of forest land to urban sprawl, to control soil erosion, to protect forests during development, to increase the use of urban wood waste, and to plant trees for energy conservation.

Soil and Water Management

The Forest Service is responsible for the forestry components of the U.S. Department of Agriculture (USDA) National Conservation Program. Soil and water management activities conducted this year in 14 states included developing and implementing pollution control programs and training 741 state forestry personnel to use the Universal Soil Loss Equation. This equation helps managers evaluate efforts to reduce erosion and maintain soil productivity.

Pest Management

State and Private Forestry encourages forest managers to practice integrated pest management so that timber, watersheds, recreation, wildlife, and visual resources are protected. This approach depends on a thorough evaluation of conditions and needs and employs the best combination of available pest suppression tactics, including silvicultural, biological, chemical, mechanical, and manual means.

Reforestation

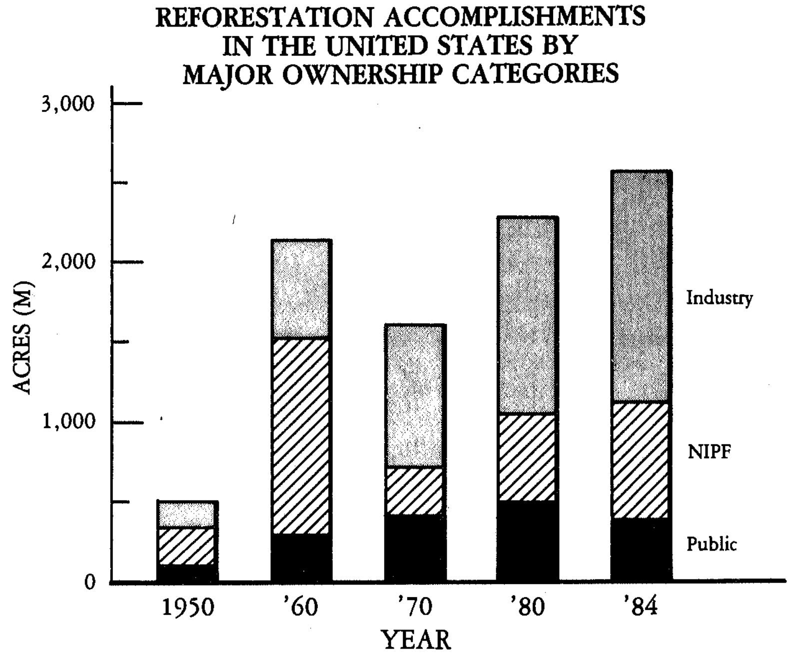
More acres were reforested during the 1983–1984 planting season than in any previous year in the history of the United States. More than 2.5 million acres were planted in all ownership categories, and the 731,000 acres planted on nonindustrial private forest (NIPF) lands—29 percent of the total—made a significant contribution. The cooperative forestry programs carried out by the USDA, Forest Service, through cooperation with state forestry organizations, are aimed at increasing the productivity of the NIPF lands.

The application of these programs results in reduction of soil erosion not only from forest lands, but also from poor crop and pasture lands as well. Although this is an increase of 100 percent over the past decade for acres planted by NIPF landowners, recent studies show that only one-third to one-half of the acres harvested on these lands are purposefully reforested. These landowners control 58 percent of the commercial forest land in the nation, and 42 percent of the nation's growing stock is on these lands. Currently these lands are producing at only 63 percent of potential. The graph (Figure 5–6) shows trends for acres planted by major ownership categories since 1950. (Note: The large acreage of NIPF in 1960 shows the impact of the Soil Bank Program.)

State Forest Planning

Statewide Forest Resources Plans are now being prepared with federal assistance under the Cooperative Forestry Assistance Act. To date, 28 final plans and

FIGURE 5-6



SOURCE: U. S. Forest Service.

11 draft plans have been completed. The objective is to install, maintain, and improve a continuing forest resource analysis and long-range forestry program planning process in each state. This process will enhance conservation and protection efforts for the environment. It will also guide public and private investment to assure adequate resource supplies to meet projected demands.

Current Environmental Quality Issues in Forest Management

Smoke Management

Fire has historically played a major role in shaping the wildland ecosystems of North America. Smoke, like fire, has been a natural component of our wildland ecosystems for millions of years. Fire and smoke cannot be totally eliminated from our wildland ecosystems without serious adverse consequences. For example, when the Forest Service attempted to protect all National Forest wildland ecosystems by *excluding* all fires, this action initially reduced both the number of wildfires and the area burned. However, over time, fuel loadings increased to the point that National Forests experienced significantly greater numbers of devastating, high-intensity conflagrations.

The Forest Service uses prescribed fire on one million acres each year to accomplish a number of specific resource management goals and objectives. The Forest Service coordinates the use of prescribed fire with state and local Air

Quality District personnel. In many parts of the United States, prescribed fire is the most cost-effective technology available for preventing catastrophic wildfires and reducing the damage they can cause.

Prescribed fire is also used for preparing planting sites, rejuvenating vegetation critical to specific wildlife species as food and cover, increasing water yields, and improving forage production. Smoke management techniques provide today's land managers with the means of protecting the quality of air while accomplishing management goals and objectives that require the use of prescribed fire.

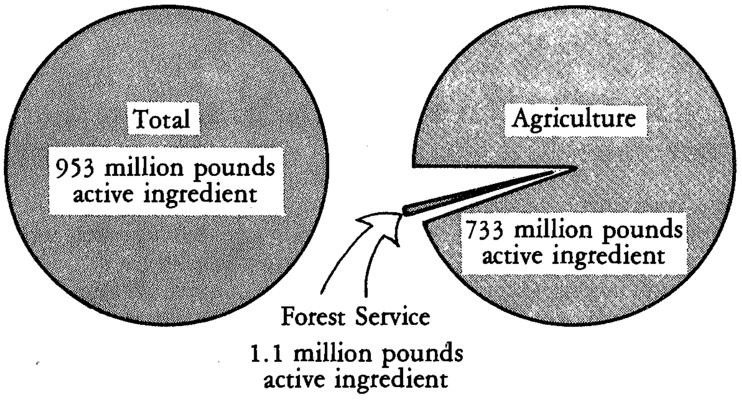
Use of Pesticides in Forestry

Resource managers and pest management specialists are working toward more complete incorporation of pest prevention and suppression needs in all resource management activities. This is an essential part of integrated pest management that strives to apply the best combination of available pest control tactics to reduce pest losses to levels commensurate with resource values. Control measures include pesticides and their judicious use in certain forest management situations.

The quantity of pesticides used by the Forest Service for pest control is minuscule in comparison with pesticide use in agriculture (Figure 5-7). It is even small in comparison to total acres managed by the agency. For example, based on a five-year average (1980–1984), approximately 535,000 acres of National Forest System land are treated with approximately 715,000 pounds of pesticides. This represents pesticide application to less than 0.2 percent of the

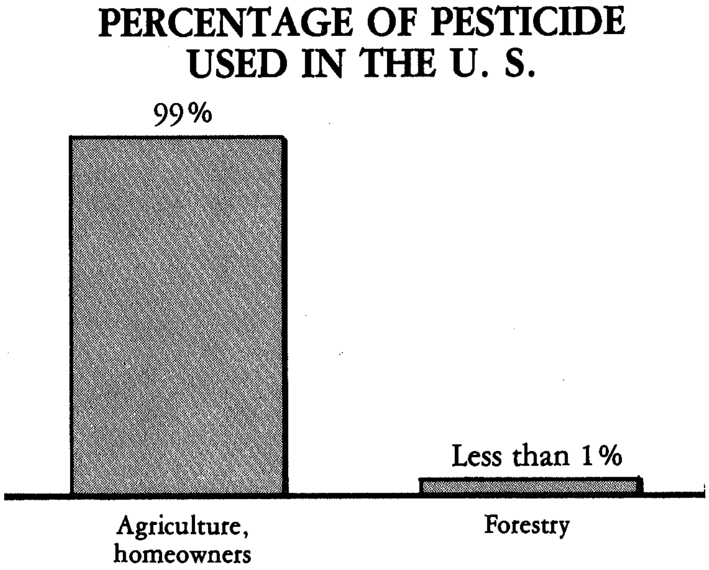
FIGURE 5-7

VOLUME OF PESTICIDE ACTIVE INGREDIENT USED IN THE U. S. - 1983



SOURCE: U. S. Forest Service.

FIGURE 5-8



SOURCE: U. S. Forest Service

191 million acres administered by the Forest Service and is a very small portion of the total amount of pesticides used in the United States (Figure 5–8). Most pesticides (about 70 percent) are applied using ground rather than aerial methods.

Controversies exist about continued use of pesticides on National Forest System land. Administrative appeals and litigation with regard to pesticide use have increased in recent years and the trend appears to point upward. At issue are procedural compliance with NEPA, aerial applications, herbicide use, chemicals versus biologicals, health effects, and drift control.

Private Landholdings: Coasts, Wetlands, and Areas of Critical Environmental Concern

The Swamp Lands Act of 1849, 1850, and 1860 granted 65 million acres of swamps and overflow lands to 15 states for reclamation to reduce flooding and drain mosquito-breeding wetlands. Wetlands were then considered a health menace and a hindrance to land development. More than a century later, the U.S. Fish and Wildlife Service (FWS) reported on an inventory of wetlands that reflected a far different perception—that vegetation-covered tidal flats, coastal salt marshes, wooded swamps and bottomlands, mangrove lagoons, and glacial bogs should be valued as wildlife habitat, and for such other beneficial purposes

"... the storage of ground water, the retention of surface water for farm uses, the

stabilization of runoff, the reduction or prevention of erosion, the production of timber, the creation of firebreaks, the provision of an outdoor laboratory for students and scientists, and the production of cash crops, such as minnows (for bait), marsh hay, wild rice, blackberries, cranberries and peat moss."[2]

This historically valuable report, "Wetlands of the United States," was issued as Circular 39 in 1956 primarily to delineate the wildlife value of wetlands. Since then, a number of studies have been published by government agencies that document the condition and ecological value of these unique land-water environments. In 1974, the National Wetlands Inventory Project was established to generate scientific information on the characteristics and extent of the nation's wetlands. Most recently, the Fish and Wildlife Service published "Wetlands of the United States: Current Status and Recent Trends" (March 1984), using the results of this inventory.

Today, wetlands comprise about 5 percent of the contiguous United States: about 99 million acres of vegetated and unvegetated wetlands, of which 95 percent are located in inland, fresh water areas; 5 percent are coastal, saltwater wetlands.[3] In addition, nearly 60 percent of Alaska, some 200 million acres, is covered by wetlands, but this figure is subject to a controversy over the classification of Alaskan tundra.

It is generally accepted that, since the nation was founded, between 30 percent and 50 percent of all wetlands in the "lower 48" states have been converted to other land uses, mostly agriculture. Approximately 215 million acres of wetlands existed in the continental United States at the time of the nation's settlement. By the mid-1950s there were an estimated 108.1 million acres. In describing recent national trends, the Fish and Wildlife Service uses the figure 458,000 acres per year as the average rate of wetland loss between then and the mid-1970s.[4] Another comprehensive review of this subject by the Congressional Office of Technology Assessment (OTA), *Wetlands: Their Use and Regulation* was also published in March 1984. OTA estimates that present national rates of conversion have slowed considerably when compared with the 20-year period of the mid-1950s to 1970s: from a net 550,000 acres lost annually then, to about 300,000 acres now. It attributes this trend primarily to declining rates of agricultural drainage and secondarily to government programs that regulate wetland use.[5]

Regardless of this downward trend, the very fact that this congressionally-initiated assessment was undertaken reflects the concern that wetland loss remains a major environmental issue. The focus of this attention will clearly be on agricultural conversions, which, although declining, are estimated by OTA to account for over 80 percent of total wetland conversions. A chapter in its report dealing with wetland trends concludes with this paragraph:

"Since data from the last 10 years are insufficient to provide an accurate estimate of current conversions of wetlands to agricultural use, future projections of wetland conversion rates cannot be made. However, *without restrictions on conversions* it can be expected that wetlands probably will continue to be converted for agricultural use. Production on newly converted wetlands may have little impact on the national need for about 400 million acres of cropland over the next 20 years or even on regional incomes from farming. *However, it may well make a difference for individual farmers.*" [Emphasis added.][6]

It is clear from this study that the traditional taxpayer- and fee-financed programs to acquire wetlands and place them in public ownership, or to regulate them under the federal dredge-and-fill permit program of the Clean Water Act, will have only limited applicability to most wetland conversions.

Of the 90 million acres in the National Wildlife Refuge System and other FWS-protected areas, about 33.4 million acres are considered wetlands, and 28.7 million of these are in Alaska. Thus the FWS controls about 4.7 million of the estimated total 99 million acres of continental wetland, or less than 5 percent. The total extent of other government agencies' ownership of wetlands is not currently available. Thus, although the FWS and other government agencies may expect to acquire other areas of unique ecological significance with federal appropriated funds or philanthropic donations, the protection of the overwhelming majority of wetlands must depend upon means other than public ownership.

The U.S. Army Corps of Engineers, which administers the only federal wetlands regulatory program (the Section 404 dredge-and-fill permit program), uses the smaller figure of 64.1 million acres as subject to its jurisdiction, excluding Alaska and Hawaii. Its impact, however, falls mainly on coastal wetlands and does not explicitly regulate drainage and some other methods of wetland conversion. Its effectiveness in preventing or mitigating wetland losses is difficult to quantify, although the OTA study credits the program with 50,000 acres of prevented loss per year, primarily through project modifications. The ever-present controversy over the costs and the regulatory details of this program and proposed reforms suggests that the practical applicability of a federal permit regime to inland agricultural operations is limited, even assuming it were desired.

Moreover, any federal regulatory program, however narrowly focused, aimed at influencing private land use will encounter resistance. This resistance stems from the deeply rooted tradition and principle of private property rights in our nation. As attention to wetland protection is directed inland (where 97 percent of the losses occurred), and towards individual agricultural activities, tensions between the private landowner and the federal government are likely to increase.

Nonetheless, although annual wetland conversions seem to be declining nationally, pressures on certain types of wetlands — coastal mangrove, bottomland hardwood, and prairie potholes, in particular — still justify federal attention. *The question, then, is how to conserve privately owned areas of critical environmental concern, which cannot be purchased by the federal government from tax or fee revenues?*

The difficulty faced by private landowners in capturing the benefits of preservation of areas of critical environmental concern is often cited as a classic example of market failure. Ironically, these "failures" of the market must be compared with the "failures" of government, particularly those stemming from statutory and regulatory policies that encourage depletion and conversion of these areas.

Federal policies are often self-contradictory. At the same time that federal and state efforts are funded to preserve wetlands, a host of other federal and state programs encourage development. Flood control and drainage projects, which make the development of wetlands technically feasible, simultaneously

reduce the risk of loss from such development. A number of provisions of the income tax code are specifically directed at wetlands drainage, and these are reinforced by the fact that generally available accelerated depreciation provisions also reduce the cost of wetlands conversion. Agricultural price support, loan, and storage programs artificially increase the value of output produced on reclaimed lands. Low interest loans and technical assistance induce many farmers to undertake agricultural drainage projects. Disaster assistance programs (crop insurance, flood insurance, emergency loans, and direct assistance) reduce the potential losses from development (agricultural, residential, commercial, and industrial) in flood prone areas. All of these programs distort market signals: they lower the cost of conversion and development and artificially increase the value of the output on the reclaimed land.

Undeveloped Barrier Islands and Coastal Wetlands

In 1982 Congress enacted, with Administration support, the Coastal Barrier Resources Act (CBRA), which eliminated most federally financed assistance programs, including federal flood insurance, for new development projects on undeveloped coastal barriers. The list of federal programs not available for new development projects includes grants, loans, rebates, and subsidies for the development or expansion of infrastructure, for example, bridges and roads. The CBRA went a long way toward eliminating the inherent contradiction of the government's policy of protecting fragile coastal barriers as habitats for wildlife and wetland nurseries while it was simultaneously promoting commercial development through the provision of federal assistance.

The practical impact of this new approach is currently under review by the Department of the Interior for its effectiveness in protecting undeveloped coastal barriers and their associated aquatic habitats. Investigations are also underway to assess the applicability of this general approach to wetlands elsewhere in the nation. The areas under study to document the possible adverse impacts of existing federal programs include the Prairie Pothole Region of the Upper Midwest, and the Lower Mississippi Alluvial Plain.

One of the products of such an examination could be the identification of precise, incremental changes that would serve to reduce the undesirable side effects that existing federal programs may be having on wetland conversion. For example, incidental incentives to drain wetlands can be eliminated by selectively excluding newly converted wetlands from these offending programs. Changes in the agricultural price support and crop insurance programs could render output on newly converted wetlands ineligible for benefits. New investments in drainage facilities could be made ineligible for the accelerated depreciation provisions of the tax code. Development on newly drained land could be excluded from coverage under emergency and disaster insurance programs. The list of marginal changes is extensive, but they would go a long way toward protecting wetlands by eliminating inconsistent government policies and reducing inefficient tax and budgetary subsidies that distort resource allocations.

Preserving Private Wetlands: The Role of Voluntary Action

Alternatives to federal and state regulation also include voluntary participation

in incentive programs, technology transfer, education and, quite simply, good example. There is ample evidence that appreciation for the intrinsic and practical value of wetlands is well established in the private sector and that many individuals and private organizations voluntarily protect these valuable ecosystems. Chapter 9 describes how one Wisconsin farmer, C. James Wallendal, manages his private property to protect wetland habitat. This individual's voluntary alternative to federal regulation relies on enlightened self-interest and can provide a model for individual landowners everywhere.

Private Landholdings: Agricultural and Other Developed Lands

The information contained in this section is derived mostly from the 1982 National Resources Inventory (NRI) data, although numerous other sources were used.[7] The 1982 NRI is one of the most comprehensive studies of the United States' natural resources ever made. This inventory was conducted by the Soil Conservation Service (SCS), in cooperation with the Iowa State University Statistical Laboratory and with guidance from the Forest Service and other federal agencies. Its objective has been to gather data on the nation's soil, water, and related resources.

The 1982 NRI is the latest in a series of national inventories conducted by SCS. The sampling design and data collection procedures were strongly influenced by four previous studies: the National Inventory of Soil and Water Conservation Needs (CNI) of 1958, the 1967 CNI, the 1975 Potential Cropland Study, and the 1977 NRI. The NRIs were authorized by the Rural Development Act of 1972 (Public Law 92–419) but have assumed a more prominent role since passage of the Soil and Water Resources Conservation Act (RCA) of 1977, which provided for periodic assessments and program development based on NRI data to be performed in the Department of Agriculture (USDA).

The 1982 NRI was designed to obtain natural resource data usable for analysis at a substate (multi-county) level. Samples for the 1982 NRI were selected using the standard statistical techniques of stratification, area sampling, and clustering. The sample for the 1982 NRI consists of nearly 350,000 Primary Sampling Units, roughly a 3.5 percent sample of the nonfederal land area of the U.S.

Information from the 1982 NRI is available to the public in several forms. Statistical tables released in July 1984 presented national estimates covering land cover/use, irrigation, conservation treatment needs, erosion, potential cropland, prime farmlands, and pastureland and rangeland condition. A USDA statistical bulletin on the 1982 NRI is being prepared for publication in late 1985. It will contain a number of the statistical tables, as well as additional information and documentation drawn from the 1982 NRI. Computer files are another source of NRI data available to qualified users through requests to SCS.

Land Quality and Use

The 1982 NRI reports the total surface area of nonfederal and federal land, census water (bodies so classified by the U.S. Census Bureau), and coastal and boundary water in the United States, excluding Alaska but including the

Caribbean, as 1.987 billion acres. (See Table 5–1.) Of this, about three-fourths (1.5 billion acres) is owned in individual parcels by private citizens, by business and industry, and by states, counties, cities, and other nonfederal units of government. The federal government administers 20 percent, or 404 million acres. About 2 percent, 48 million acres, consists of the coastal and boundary water as defined by the Bureau of Census.[8]

The 1.5 billion acres of nonfederal land was used as follows: 28.3 percent cropland (421 million acres); 8.9 percent pastureland (133 million acres); 27.3 percent rangeland (406 million acres); 26.5 percent forestland (394 million acres); and 4.9 percent urban and built-up areas, roads and highways (74 million acres); and the rest, 4.1 percent, other nonfederal rural land (59 million acres). (See Figure 5–9.)

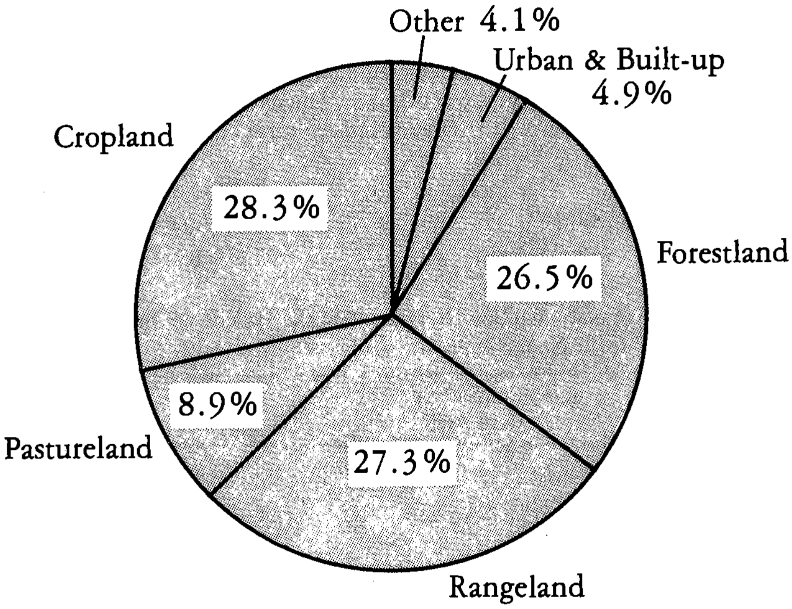
TABLE 5–1. LAND AND WATER IN THE UNITED STATES AND CARIBBEAN AREA (Excludes Alaska[1])

Type of Surface Surface Area	Million of Acres 1977	1982
Land		
NONFEDERAL		
Forestland	370	394
Rangeland	408	406
Cropland	413	421
Pastureland	134	133
Other	166	133
Total Nonfederal Land	1,491	1,487
FEDERAL	402	40
Total Land Area	1,893	1,891
Water		
Small Water	9[2]	10[2]
Coastal and Boundary Water	48[3]	48[3]
Census Water	38[4]	39[4]
Total Water Area	95	96
TOTAL LAND AND WATER	1,988	1,987

[1]Data for nonfederal lands and water are from 1977 and 1982 National Resource Inventories. SCS adjusted county base data from 1970 Bureau of Census data; data for federal lands from Forest Service. Because of the technical improvements in the collection of the data, comparison of the 1977 and 1982 NRIs should be done with caution.
[2]Small water bodies are streams and rivers less than 1/8 mile wide and other water bodies less than 40 acres in size. Small water bodies are not counted as water by the Census Bureau.
[3]Includes the Great Lakes and large estuaries.
[4]Large water bodies (counted as water by the Census Bureau) are lakes and reservoirs more than 40 acres in size, and streams and rivers more than 1/8 mile wide.

FIGURE 5-9

USE OF NON-FEDERAL LAND IN 1982 (%)



SOURCE: 1982 National Resources Inventory.

Use of Land by Capability

USDA uses a land classification system that groups soils on the basis of their ability to produce common cultivated crops and pasture plants without deterioration.[9] Capability classes are designated by numbers I through VIII. Within each capability class there are subclasses reflecting characteristics that place significant limitations on the soil use. As the numbers rise, they indicate progressively greater limitations and narrower choices for practical use. Table 5–2 indicates cropland use in 1982, by land capability class and subclass.

On the whole, in 1982, the various classes of private land in the nation were being used rationally. Almost all of America's Class I land, the most suitable class for farming, was used for row crops. Classes II and III supply the majority of our cropland, although they generally require the application of conservation measures for resource protection. Another 47 million acres of cropland are in Class IV. Soil conservation on Class IV lands is often expensive and difficult to apply and maintain. In the more restricted land Classes V–VIII there were approximately 19 million acres of cropland, 32 million of pastureland, 289 million of rangeland, and 229 million in forestland.

TABLE 5-2. CROPLAND USE IN 1982, BY LAND CAPABILITY CLASS AND SUBCLASS* (1,000 acres)

CLASS AND SUBCLASS	TOTAL NONIRRIGATED CROPLAND	TOTAL IRRIGATED CROPLAND	TOTAL CROPLAND
I	21,528.2	8,690.9	30,219.1
IIe	82,268.2	9,094.9	91,363.1
IIW	60,783.3	4,168.5	64,951.8
IIs	10,236.0	6,951.0	17,187.0
IIc	15,823.8	1,934.7	17,758.5
ALL II	169,111.3	22,149.1	191,260.4
IIIe	76,033.0	6,687.3	82,720.3
IIIW	25,106.5	8,185.2	33,291.7
IIIS	8,696.5	3,801.6	12,498.1
IIIC	4,524.6	640.0	5,164.6
ALL III	114,360.6	19,314.1	133,674.7
I-III	305,000.1	50,154.1	355,154.2
IVe	28,407.2	4,072.0	32,479.2
IVw	5,597.1	1,594.2	7,191.3
IVs	5,065.9	1,756.0	6,821.9
IVc	318.7	151.7	470.4
ALL IV	39,388.9	7,573.9	46,962.8
I-IV	344,389.0	57,728.0	402,117.0
V	1,904.1	452.6	2,356.7
VIe	8,902.4	1,026.2	9,928.6
VIw	798.4	382.6	1,181.0
VIs	2,350.3	451.0	2,801.3
VIc	144.5	49.2	193.7
ALL VI	12,195.6	1,909.0	14,104.6
VIIe	1,209.0	94.6	1,303.6
VIIw	176.7	121.9	298.6
VIIs	960.4	162.8	1,123.2
VIIc	51.1	13.2	64.3
ALL VII	2,397.2	392.5	2,789.7
VIII	24.6	9.9	34.5
V-VIII	16,521.5	2,764.0	19,285.5
NA	0.0	0.0	0.0
TOTAL	360,910.5	60,492.0	421,402.5

*Capability subclasses indicate the main soil limitation as follows:
e— erosion c— climate
w— wetness s— rooting zone limitations

Source: 1982 National Resources Invetoty

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Land Use Trends

There have been successive efforts to inventory the nation's resources, but comparing their findings is sometimes difficult because of procedural differences and technological improvements in more recent inventories. Most notably, some acreage classified as built-up in the 1977 NRI[10] was reclassified as rural land in 1982. Despite these procedural differences, some general land use trends can be detected from the 1982 NRI and preceding inventories conducted by SCS and other federal agencies.[11] (See Table 5-3.)

Cropland

Nonfederal land used as cropland has decreased since 1958. In the period 1958 to 1982 there has been a decrease of 28 million acres, from 449 million acres to 421 million acres. In the past few years, however, the total cropland acreage has remained relatively constant with a slight increase (about 8 million acres) from 1977 to 1982. Part of this increase is because some land classified as urban and built-up in 1977 was redefined as cropland in 1982.

TABLE 5-3. TRENDS IN THE USE OF NONFEDERAL LAND

Use of nonfederal rural land, 1967-1982 (percent)

Land Use	1967[1]	1977[2]	1982[3]
Cropland	29.9	29.5	29.8
Pastureland	35.2[4]	9.5	9.4
Rangeland	—	29.1	28.7
Forestland	30.9	26.4	27.9
Other rural land	4.0	5.5	4.2
TOTAL	100.00	100.0	100.0

[1]Unadjusted data, 1967 Conservation Needs Inventory.
[2]1977 NRI.
[3]1982 NRI.
[4]Includes rangeland.

Nonfederal land uses (million acres), 1967-1982

Land Use	1967[1]	1977[2]	1982[3]
Rural land[4]	1,438	1,401	1,414
Urban built-up, rural transportation	61	90	74
Small water	7	9	10
TOTAL	1,506	1,500	1,498

[1]Unadjusted data, 1967 Conservation Needs Inventory.
[2]1977 NRI.
[3]1982 NRI.
[4]Includes cropland, pastureland, rangeland, forestland, and minor land cover/uses.

About 153 million acres not currently cropped have high or medium potential for conversion to cropland. Of this potential cropland, 71 percent is grazing land and 27 percent is forestland. However, 93 million acres of these lands are fragile lands. Overall, this evidence suggests that we have some additional capacity to boost food production, if needed, by bringing more land into production.

The acreage of irrigated cropland has greatly increased. In 1958, 37 million acres were irrigated. By 1967, 48 million acres were irrigated, and by 1982, 60 million acres. The rate of increase in irrigated acres has slowed recently due to energy costs and the lowering of ground water aquifers.

Urban Land

In 1981 evidence on farmland conversion trends became available in conjunction with the National Agricultural Lands Study (NALS). Based on the 1967 CNI and the 1977 NRI land use information, the NALS estimated that up to 3 million acres of rural land were being converted to nonagricultural uses each year, of which about 1 million acres was from the cropland base.[12] Several observers have argued that these data may have significantly overstated the magnitude of farmland losses.[13,14] The issue is clear: Should we be concerned or not about the amount of U.S. farmland, and of cropland in particular, that is being converted into urban uses?

The 1982 NRI and other recent information indicated the likely amount of conversion is only about one-third of the amount initially estimated by NALS—about 900,000 acres of rural land per year.[15] In 1982 there were nearly 74 million acres of urban and built-up land. This is considerably less than the projected 90 million acres estimated in 1977. The 1977 NRI overestimated urban and built-up areas because of the methods used to obtain the data, limited availability of mapping materials, and map scale and measurement problems.

Also, more than 80 percent of U.S. cropland (and land that could be converted to cropland) lies in rural areas subject to little or no urban encroachment. Based on this latest information, urbanization appears to present little threat to most U.S. farmland. However, conversion of farmland to other uses is an important issue in certain regions, especially those of rapidly expanding urban growth. For example, cropland in the Northeast is under more urbanization pressure than elsewhere because more than three-fourths of it is within or adjacent to urban counties. Ownership patterns of cropland are also different in metropolitan counties, with a higher proportion held in small parcels, by nonfarmers, and by nonfamily corporations than in rural areas. Such differences in ownership patterns may presage conversion of cropland to other uses.[16]

While we should not be complacent about the agriculture land conversion issue, neither is it a matter of pressing current national concern.

Pastureland and Rangeland

The acreage of grazing land increased from 486 million acres in 1958 to 548 million acres in 1977. Most of this change occurred from 1967 as a result of redefinition of rangeland and forestland. In 1982 there were 539 million acres of land available for grazing. The decrease in grazing land between 1977 and

1982 reflects the plowing out of some fragile rangelands (sodbusting) to produce crops.

Forestland

About 60 percent of the nation's forestland is privately owned—three-fourths of which is in the eastern part of the country. As a result of the nation's future needs for crop and pastureland, roads, and urban space, the area of forestland is expected to decrease 19 million acres by 2030. As a consequence, there are likely to be some significant impacts, expecially on timber supplies in the South, where most of the conversion is expected to take place. Despite the projected losses, the nation will still have a large forestland base in 2030 and beyond. The major problem will not be one of size, but rather one of how to manage the available land in ways that achieve a larger part of the productive potential.[17]

Prime Farmland

As of 1982 there were about 342 million acres of prime farmland in the United States compared to 345 million measured in 1977 (Table 5–4). Prime farmland is the land that is best suited for producing food, feed, forage fiber, and oilseed crops. Prime farmland has the soil quality, growing season, and water supply needed to produce economically a sustained high yield of crops when it is treated and managed using acceptable methods.[18] About 68 percent of the prime farmland, or 232 million acres, is cropland. Prime farmland accounts for a large share of the cropland in the major farming regions of the United States. The Corn Belt, for example, has 22 percent of the cropland in the country, 90 percent of which is prime farmland. By contrast, the Mountain Region has 10 percent of the cropland, of which only 22 percent is prime farmland.

One hundred and ten million acres of prime farmland, nearly a third of the total, are not used for cultivated crops: 39 million acres of pastureland, 20 million acres of rangeland, 44 million acres of forestland, and 7 million acres of farmsteads, roads, feedlots, or similar land uses.

Soil Erosion

Soil is eroded mainly by wind or moving water. The erosion caused by moving water is categorized as sheet, rill, gully, and streambank erosion. Sheet erosion removes soil fairly uniformly in a thin layer; rill erosion removes soil in small channels formed from concentrated flow. They are the major types of erosion on cropland, yet they may go largely unnoticed. Wind erosion is a major problem in areas of high wind velocity and low rainfall. Most wind erosion occurs in the Great Plains states and in the Southwest.

In 1982 more than 3.4 billion tons of sheet and rill erosion and 2.0 billion tons of wind erosion occurred on nonfederal lands. Based on a 1978 survey, gully erosion, together with erosion from streambanks, roadbanks, and construction sites, accounts for another 1.1 billion tons annually.[19] Therefore, total soil erosion on all nonfederal land was around 6.5 billion tons in 1982.

The national average for sheet and rill erosion on cultivated cropland was 4.8 tons per acre in 1982 compared to 5.1 tons per acre in 1977 (Figure 5–10).

TABLE 5–4. PRIME FARMLAND IN 1982, BY STATE

State	Cropland			Pastureland	Rangeland	Forest land	Cover/Uses	Total
	Nonirrigated	Irrigated	Total					
Alabama	2,829.9	59.9	2,889.8	1,497.1	0.0	2,749.6	134.3	7,270.8
Arizona	0.0	1,059.8	1,059.8	31.0	0.0	0.0	0.0	1,090.8
Arkansas	3,854.5	2,786.9	6,641.4	2,226.0	4.8	2,675.4	76.9	11,624.5
California	107.3	5,437.4	5,544.7	256.4	44.9	5.2	39.8	5,891.0
Colorado	0.0	1,596.7	1,596.7	74.2	0.0	0.0	15.3	1,686.2
Connecticut	134.3	7.4	141.7	35.0	0.0	148.4	29.9	355.0
Delaware	309.4	18.0	327.4	22.3	0.0	68.3	12.9	430.9
Florida	396.4	23.3	419.7	152.1	0.4	520.3	12.3	1,104.8
Georgia	3,218.6	665.0	3,883.6	980.5	0.0	2,673.4	190.8	7,728.3
Hawaii	69.0	174.4	243.4	43.3	0.0	9.8	0.0	296.5
Idaho	743.5	2,293.1	3,036.6	272.9	55.5	11.5	36.9	3,413.4
Illinois	19,002.4	86.6	19,089.0	1,147.2	0.0	679.4	337.7	21,253.3
Indiana	11,084.2	106.4	11,190.6	915.1	0.0	1,027.2	377.7	13,510.6
Iowa	16,610.9	73.0	16,683.9	1,245.0	0.0	224.5	529.6	18,683.0
Kansas	16,237.7	2,769.3	19,007.0	1,345.4	4,665.3	251.4	333.3	25,602.4
Kentucky	3,745.2	11.8	3,757.0	1,505.6	0.0	615.8	172.3	6,050.7
Louisiana	4,472.6	1,181.0	5,653.6	1,592.5	15.0	5,488.0	226.3	12,975.4
Maine	385.5	3.0	388.5	135.2	0.0	679.2	70.8	1,273.7
Maryland	811.7	27.4	839.1	125.5	0.0	250.9	33.9	1,249.4
Massachusetts	137.0	1.8	138.8	62.0	0.0	165.9	15.0	381.7
Michigan	5,524.2	183.3	5,708.5	687.5	0.0	1,187.4	216.5	7,798.9
Minnesota	15,942.4	108.7	16,051.1	1,096.9	73.0	2,992.6	624.4	20,838.0
Mississippi	4,877.3	477.4	5,354.7	1,781.1	0.0	3,088.1	116.8	10,340.7
Missouri	9,173.8	689.4	9,863.3	3,760.8	73.9	1,104.9	197.2	15,000.1
Montana	21.9	836.0	857.9	138.9	4.6	1.3	12.2	1,104.9
Nebraska	5,697.4	4,902.8	10,600.2	541.5	692.1	85.2	324.2	12,243.2

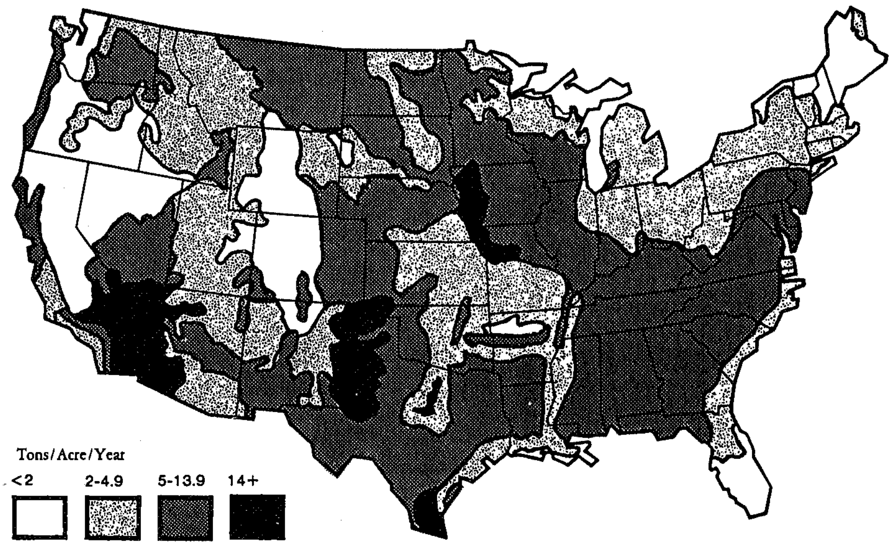
TABLE 5-4. PRIME FARMLAND IN 1982, BY STATE—Continued

State	Cropland			Pastureland	Rangeland	Forest land	Cover/Uses	Total
	Nonirrigated	Irrigated	Total					
Nevada	0.9	284.2	285.1	23.3	2.1	0.0	3.0	313.5
New Hampshire	40.6	2.9	43.5	12.6	0.0	71.5	16.8	144.4
New Jersey	380.6	68.0	448.6	82.1	0.0	294.7	38.1	863.5
New Mexico	0.0	573.9	573.9	37.4	0.0	0.0	3.8	615.1
New York	2,689.8	43.0	2,732.8	950.3	0.0	1,380.6	74.6	5,138.3
North Carolina	2,672.8	135.2	2,808.0	479.1	0.0	2,179.2	213.3	5,679.6
North Dakota	12,563.2	119.5	12,682.7	249.1	602.4	72.7	306.0	13,912.9
Ohio	9,743.3	20.9	9,764.2	791.4	0.0	1,234.5	458.2	12,248.3
Oklahoma	7,414.4	494.5	7,908.9	3,336.8	3,014.8	667.5	121.0	15,049.0
Oregon	523.9	816.6	1,340.5	359.3	36.6	156.7	42.2	1,935.5
Pennsylvania	2,175.4	6.1	2,181.5	537.8	0.0	1,412.7	153.3	4,285.3
Rhode Island	19.2	3.8	23.0	13.5	0.0	41.1	1.0	78.6
South Carolina	1,618.1	42.6	1,660.7	392.0	0.0	1,290.4	85.8	3,428.9
South Dakota	5,090.0	258.0	5,348.9	428.1	414.1	14.6	220.6	6,426.3
Tennessee	3,401.1	14.5	3,415.6	1,570.0	0.0	1,203.1	128.9	6,317.6
Texas	13,271.2	5,958.6	19,229.8	5,526.1	10,198.1	2,321.6	345.7	37,621.3
Utah	16.6	716.0	732.6	51.6	0.7	0.0	2.6	787.5
Vermont	171.4	0.0	171.4	67.0	0.0	91.5	6.1	336.0
Virginia	1,681.6	75.8	1,757.4	522.8	0.0	2,648.6	103.9	5,032.7
Washington	504.5	914.0	1,418.5	353.1	8.4	454.0	74.0	2,308.0
West Virginia	316.6	2.8	319.4	108.7	0.0	99.3	11.7	539.1
Wisconsin	6,198.4	89.8	6,288.2	790.3	0.0	2,117.6	218.3	9,414.4
Wyoming	4.2	289.2	293.4	24.1	21.3	0.0	10.6	349.4
Caribbean	58.9	63.2	122.1	137.6	0.0	3.9	1.3	264.9
Total	195,944.7	36,573.0	232,517.7	38,515.1	19,928.0	44,459.5	6,778.0	342,198.3

Source: 1982 NRI - (July 1984).

FIGURE 5-10

AVERAGE ANNUAL SHEET, RILL, AND WIND EROSION ON CROPLAND



SOURCE: 1982 National Resource Inventory.

Erosion on pastureland and rangeland averaged 1.4 ton per acre; grazed forestland erosion rates averaged 2.3 ton per acre; and soil loss on ungrazed forestland averaged 0.7 ton per acre. These rates of sheet and rill erosion are generally slightly lower than those reported in the 1977 NRI.

Wind erosion data were collected for all states (except Alaska) for the first time in the 1982 NRI. Wind erosion on cultivated cropland averaged 3.3 tons per acre. On rangeland, the national average was 1.5 tons per acre.

Soil loss tolerance (T) is defined by USDA as the maximum average annual soil loss that will permit a high level of production, economically and indefinitely, on a specific soil. Soil erosion becomes a threat to productivity only when the annual rate of erosion exceeds the soil loss tolerance. The T value is normally about 5 tons per acre, but can be lower on some soils. About 56 percent of all cropland is eroding at levels equal to or less than T. Erosion on those lands without excess erosion totalled only 18 percent of all soil erosion on the nation's cropland. Nationwide this is a general improvement compared to 1977 conditions. Still, about 44 percent of all cropland is eroding at levels greater than T, while almost all pastureland and forestland is eroding at less than T, and roughly 12 percent of rangeland is eroding at levels exceeding 2T (Table 5–5).

Fragile Land

Extensive plow out (conversion of previously uncultivated land to cropland) of land has occurred in the past decade. The most dramatic examples of plow

TABLE 5-5. SHEET AND RILL EROSION BY MAJOR LAND USE, 1982 NRI

Land Use	Total	Categories of average annual sheet and rill erosion					
		<T	%	T-2T	%	>2T	%
Cropland:							
Area (million acres)	421.4	315.6	75	54.9	13	50.9	12
Erosion (million tons)	1,843.4	506.8	27	328.8	18	1,007.8	55
Erosion rate (tons/acre)	4.4	1.6	—	6.0	—	19.8	—
Pastureland:							
Area (million acres)	133.3	122.0	92	5.5	4	5.8	4
Erosion (million tons)	180.1	59.8	33	26.3	15	94.0	52
Erosion rate (tons/acre)	1.4	0.5	—	4.8	—	16.2	—
Rangeland:							
Area (million acres)	405.9	355.2	88	21.8	5	28.9	7
Erosion (million tons)	561.7	182.9	33	63.4	11	315.4	56
Erosion rate (tons/acre)	1.4	0.5	—	2.9	—	10.9	—
Forest land:							
Area (million acres)	393.7	370.6	94	9.7	2	13.4	4
Erosion (million tons)	370.0	99.1	27	35.2	9	235.7	64
Erosion rate (tons/acre)	0.9	0.3	—	3.6	—	17.6	—
Other rural land:*							
Area (million acres)	54.4	46.9	86	1.1	2	6.4	12
Erosion (million tons)	461.2	11.0	2	6.0	1	444.2	97
Erosion rate (tons/acre)	8.5	0.2	—	5.5	—	69.4	—

*Excludes 5.2 million acres of small built-up areas.

outs are those of prairie grassland in the western Great Plains. In several states this plow out has become a highly emotional and sometimes frightening issue. Short-term gains that individuals might get from plowing out or "sodbusting" are often negated within three to five years by wind erosion, loss of moisture, and loss of organic matter. The land may not recover for decades. A number of counties have already passed ordinances in Colorado and Montana to limit sodbusting.

Although 8 million acres went from grass and trees to cropland from 1977 to 1982, nearly half of this increase—about 4 million acres—was fragile land that has a high erosion hazard, is of marginal value for crop production, and has low potential for remaining in crop production. Viewed in overall terms, between 1977 and 1982, cropland in capability classes IVe, VIe, VII, and VIII increased 9.2 percent, while cropland in the better quality classes, I, II, and III, increased only 1.2 percent (Table 5-6). This 9 percent increase in the amount of fragile cropland occurred during a period when federal farm programs were attempting to reduce surplus crop production at significant cost to the taxpayer.

TABLE 5-6. TRENDS IN USE OF CROPLAND BY CAPABILITY CLASS (%)

Use as Cropland by Capability Class	Year 1950	1958	1967	1977	1982
I-III	82	83	84	85	84
IV	10	11	11	11	11
V-VIII	8	6	5	4	5
TOTAL	100	100	100	100	100

Source: Linda K. Lee, "Land Use and Soil Loss: A 1982 Update," *Journal of Soil and Water Conservation* 39:4 (July-August, 1983).

This shift in land use from grass and trees to cropland on marginal land causes many problems. Average erosion rates on this marginal land can be expected to be greater than 15–20 tons per acre. This is five to seven times the rate that can be matched by the soil's regenerative capacity on these lands. Excessive erosion deteriorates the long-term productive capability of the land. Sediment produced from the eroding land affects water quality and fills streams, farm drainage ditches, and road ditches.

Much of the trend toward range plow out is due to declining cattle prices and the relative attractiveness of growing crops, such as wheat, for which USDA administers production adjustment programs. These commodity programs have added to the incentives for plowing out land both by raising commodity prices and by reducing producer risk.

A policy issue presently being debated by the Congress is whether federal agricultural program benefits should be denied to agricultural commodities produced on such fragile lands. Those concerned question the wisdom of providing incentives to reduce the long-term sufficiency of our land base by lowering the costs of bringing additional land into production, while ignoring the environmental consequences of using fragile land more intensively.

USDA is presently studying classification systems that are alternatives to the existing capability classification system. These new systems classify soils on the basis of inherent erodibility and response to conservation treatment. There is no complete scientific and technical agreement to begin use immediately of an alternative system.[20]

Cost of Erosion

Erosion costs include both on-farm losses of soil productivity and off-farm damage, such as degradation of water quality and loss of recreational values. Research has begun on the impact of erosion on national crop production. In the Corn Belt, 83 percent of the cropland would have only an 8 percent or less loss in productivity in the next 100 years if erosion rates remain constant and farmers practice high levels of management, according to this research.[21] On the remaining 17 percent of the Corn Belt cropland, loss of productivity would exceed 8 percent. On some shallow soils, productivity loss would approach 50 percent. Research outside the Corn Belt is incomplete. This and other research, including analysis of the USDA Erosion Productivity Impact Calculator

(EPIC), will begin to provide national-level data in 1985. The estimated annual on-farm productivity losses from erosion are on the order of $1.3 billion.[22] However, recent research suggests that, for the nation as a whole, the costs of off-farm erosion damage may be greater than the costs of on-farm productivity losses. The Conservation Foundation estimates that off-farm damage costs from erosion range from $3.2 to $13 billion annually compared to about $2.2 billion attributable to cropland (Table 5–7).[23]

Controlling Erosion

Erosion control is accomplished through the application of conservation systems. A resource management system (RMS) is a combination of conservation practices and management identified by the primary use of land or water. Under a RMS, the resource base is protected by meeting acceptable soil losses and maintaining acceptable ecological and management levels for the selected resource use. A RMS can include: conservation tillage, terraces, waterways, diversions, contour farming, streambank protection, field windbreaks, and other such practices.

Among the most successful component of these systems are various forms of conservation tillage. Conservation tillage is defined as those methods of farming that maintain adequate plant cover or residue on the land to reduce soil erosion, increase the infiltration rate of water into the soil, reduce evaporation of water from the soil, and reduce energy consumption on the farm. Conservation tillage requires special planting equipment and careful crop management, especially in the use of pesticides for weed control instead of periodic plowing.

TABLE 5–7. OFF-SITE DAMAGES FROM SOIL EROSION
(In millions of 1980 dollars)

Type of Damage	Range of Single Value Estimates		Cropland Estimates	
Share				
Instream Damages:	950–	5,600	2,100	830
Damages to water-storage facilities	310–	1,200	640	200
Costs of navigation Impacts	420–	800	560	180
Other instream damages	420–	2,800	830	330
Total instream damages	2,100–	10,000	4,100	1,500
Off-stream Damages:				
Sediment-related flood damages	490–	1,400	770	250
Water conveyance facilities	140–	300	200	100
Water treatment for municipal and industrial use	50–	500	100	30
Other off-stream effects	410–	870	800	280
Total off-stream damages	1,100–	3,100	1,900	660
TOTAL OFF-SITE DAMAGES	3,200–	13,000	6,000	2,160

Source: Conservation Foundation.

Conservation tillage is being adopted faster than any other practice in farming history. In 1982, 23.7 percent of the nation's cropland—nearly 100 million acres—was farmed under conservation tillage, compared to just 30 million acres a decade earlier. In 1983, farmers used conservation tillage on 31.3 percent of the acres planted to crops, a 7 percent increase over 1982.[24]

But progress remains possible. Additional conservation treatment is needed on more than half of our cropland, two-thirds of our forest land, and three-fourths of our pasture and range.

Nonpoint Source Pollution From Agricultural Land

The identification and definition of water pollution problems is the responsibility of the U.S. Environmental Protection Agency and its counterpart state agencies. The reduction of pollution in the 11 years since the passage of the Clean Water Act (PL 92–500) has focused attention on the contribution of nonpoint sources as well as point sources. Six out of 10 EPA Regional Offices assert that nonpoint source pollution is the principal remaining cause of water quality problems and contend that the national goals and objectives of the Clean Water Act will not be met without an accelerated and concerted effort directed to nonpoint sources.

EPA's Federal/State/Local Nonpoint Source Task Force defines nonpoint source pollution as "a diffuse source of water pollution that does not discharge through a pipe." Examples include runoff from construction sites, mining, agricultural, and silvicultural land uses, and urban areas. Nonpoint source pollutants may be carried into streams and lakes, both over the surface and through the soil. Natural factors, such as wind, rainfall runoff, and snow melt, govern the transport of these pollutants.

Agricultural and silvicultural land uses are, by virtue of the acreages devoted to these activities, the principal sources of nonpoint source pollution. The most pervasive agricultural nonpoint source pollutants are sediments, dissolved salts, pesticides, nutrients, and bacteria. These may be transported to surface water by rain and irrigation water runoff or to ground water by infiltration.

A variety of data gaps have prevented the development of a consistent national assessment of nonpoint source water quality problems, but the following discussion provides some insight into its widespread distribution and relative importance.

In 1984 EPA's 305(b) Draft Report cited that 50 percent of the states believe that nonpoint source problems were a major or significant cause of their remaining water quality problems.[25] A survey by the Association of State and Interstate Water Pollution Control Administrators in 1984 showed that this percentage increased to 78 percent when compared to point source problems. The North American Lake Management Society Survey[26] showed that 37 of 38 states surveyed indicated that nonpoint sources of pollution seriously affected lake water quality. Fisheries surveys in 1982 indicated that 38 percent of the nation's waters had adverse effects on fishing from nonpoint sources of pollution.

The Department of Agriculture is giving increased attention to nonpoint source pollution problems as it provides educational, technical, and financial assistance to farmers. For example, $70 million was appropriated, to remain available until expended (estimated to be in the mid-1990s), to test and evaluate

the effectiveness of conservation practices in resolving nonpoint source water quality problems.

Regional programs are increasing the federal government's emphasis on nonpoint source problems. Examples include the U.S. and Canadian Governments' commitment to implement Annex 3 to the 1978 Water Quality Agreement for the Great Lakes, where the majority of the phosphorus load reduction is expected to come from on-farm nonpoint source control efforts. Salinity will be addressed in the Colorado River Basin, pursuant to a U.S. treaty with the Republic of Mexico, through the Colorado River Basin Salinity Control Act of 1974 and its amendments enacted in 1984.

The highly publicized and visible Chesapeake Bay cleanup effort is another example of combined federal, state and local efforts to reduce agricultural and other nonpoint source pollution. Five states and the District of Columbia, as well as EPA and USDA, are involved in the Chesapeake Bay Program. An important part of this effort is encouraging farmers in the Bay's drainage basin to control the loss of sediment and nutrients from their land. The strategies being developed and implemented include educational programs, cost-sharing, and increased technical assistance to apply management practices. See Chapter 2, Water Quality, for fuller discussion of this effort.

In December 1983 the Federal/State/Local Nonpoint Source Task Force made recommendations to the Administrator of EPA, which called for the development of a National Nonpoint Source Policy, which in lieu of specific legislation, would accelerate and focus the combined resources of federal, state, and local agencies on identified impaired water uses resulting from nonpoint source pollution. In these recommendations no distinction was made between surface and ground waters, as many nonpoint source control methods impact on both.

The 1985 assessment being prepared by USDA pursuant to the Soil and Water Resources Conservation Act (RCA) is putting more emphasis on the off-site effects of agricultural land uses, and it is expected that this process will aid efforts to document areas where the probability of ground or surface water problems are high. This will improve USDA's ability to direct resources to those areas with soil erosion that is critical from both an on-site and off-site perspective.

In addition, EPA is working to establish a 1984 nonpoint source pollution baseline through a reassessment of impaired water as determined by state agencies. The matching of the land and water based inventories will significantly aid in future nonpoint source pollution abatement efforts.

Conservation Programs in USDA

The Soil and Water Resources Conservation Act of 1977 (RCA) directed USDA to carry out a continuing appraisal of the soil, water, and related resources of the nation and "to develop in cooperation with and participation by the public through conservation districts . . . a national soil and water conservation program."

The first National Conservation Program (NCP) was sent to Congress by President Reagan in December 1982. It covered the 5-year period 1983–1987 and outlined the direction of soil and water conservation programs administered by USDA. The NCP contains three primary action components:[27]

1. Redirect conservation efforts more strongly to national priorities by focusing on priority problems, including targeting and assistance to geographic areas where those problems are most concentrated.

2. Strengthen the role of state and local conservation agencies in addressing resource problems and reinforce the federal-state-local partnership in the conservation efforts.

3. Improve USDA program management and coordination in ways that enhance program performance.

The NCP established two national conservation priorities: (1) to reduce excessive soil erosion on agricultural land; and (2) to conserve water used in agriculture while reducing flood damages in small upstream watersheds.

Most soil and water conservation programs are administered at the local level through soil and water conservation districts. The districts are authorized by state laws to study soil and water conservation problems, develop conservation programs, and provide technical and financial assistance to private landowners.

From 1979 to 1983, state and local governments increased their combined contribution to conservation by 17 percent to $224 million. State and local funds provided nearly 4,700 employees to conservation efforts in 1983, compared to the approximately 14,000 employees in the Soil Conservation Service. Table 5–8 compares recent trends in USDA funds for technical and financial assistance and state, local, and private contributions for soil and water conservation.

TABLE 5–8. SOURCE OF FUNDING FOR CONSERVATION PROGRAMS

Source	Funding in constant 1983 dollars 1979	1980	1981	1982	1983	Change since 1979
	millions					%
USDA	$602	$573	$543	$505	$483	−20
State and local	192	206	202	197	224	+17
Private	91	99	86	85	97	+7
TOTAL	885	878	831	787	804	−9

Source: U.S. Department of Agriculture, Soil and Water Conservation, Background for 1985 Farm Legislation, USDA, Agricultural Information Bulletin, Number 486, (January 1985).

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Chapter 6

Fish and Wildlife

It is widely acknowledged that the "modern" environmental movement found much of its inspiration in a classic volume that had a worldwide impact. Rachel Carson's *Silent Spring*, published in 1962, advanced the argument that the ubiquitous use of synthetic organic chemicals, DDT in particular, was having a devastating impact on the reproduction of birds and animals at the top of the food chain, that insects were growing resistant to insecticides, and that evidence of the potential of these chemicals to effect human cellular dysfunction was abundant, albeit circumstantial.[1]

Popular appreciation for wildlife was first awakened in this country at the end of the 19th Century as a result of the decimation of the American bison herds, the extinction of the passenger pigeon, once the most numerous of all native American bird species, and the slaughter of egrets and other spectacular wading birds for their fashionable plumage. But it was not until *Silent Spring* that the public began to recognize that the integrity and diversity of the nation's wildlife populations was a reliable indicator of the general health of the nation's environment.

As a result of this new perspective on the impact of human activity on natural systems, legislation was enacted to regulate the production and use of pesticidal and industrial chemicals, and DDT ultimately was banned completely. Programs of research, fish and wildlife management, and habitat protection were established in many agencies of the federal government, and private efforts propelled the expansion of U.S. conservation activities into the international sphere. This chapter discusses a selection of the major fish and wildlife program efforts that received federal attention during the past year. The status and condition of fish and wildlife populations and programs are also discussed elsewhere in this report, particularly in Chapter 2, on water quality; in Chapter 9, on private conservation efforts; and in Chapter 11, on international activities.

In addition, the Council invites the reader to consult the newly released *Audubon Wildlife Report, 1985*, published by the National Audubon Society.[2] It is the most current, and perhaps most comprehensive account of the condition of a wide spectrum of wildlife species and the federal programs that protect and manage these populations. This commendable private publication makes a substantial contribution to the growing corpus of conservation literature.

Marine Mammals: Whales and Whaling

Commercial whaling in the latter 1800s and early 1900s reduced one population of great whales after another, leaving only a small fraction of many original populations. In 1931, almost 50 nations signed the Convention for the Regulation of Whaling to manage whaling throughout the world. The efforts of this group were unsuccessful, as major whaling nations like Japan and the Soviet

Union did not sign this agreement. In 1946, 15 nations, including the United States, Norway, and the U.S.S.R., signed the International Convention for the Regulation of Whaling, which led to establishment of the International Whaling Commission (IWC).

Since 1949, the IWC has managed commercial whaling by establishing catch limits. Even though one of the objectives of the IWC is to conserve whale stocks, the catch limits it established continued to allow harvesting at levels that greatly decreased populations of the great whales.

The U.S. and other nations attending the 1972 United Nations Conference on the Human Environment in Stockholm agreed that a moratorium on commercial whaling should be imposed to restore whale populations. Since then, the U.S. and many other nations have worked within the mechanisms of the IWC to achieve the end of commercial whaling.

Countries with strong conservation policies achieved a major goal in 1982 when the IWC established zero quotas for commercial whaling beginning with the 1985–1986 whaling season, thereby signalling the start of the moratorium on commercial whaling. However, under the IWC procedures, member nations are allowed to file objections to IWC rules and continue whaling. Japan, the Soviet Union, Norway, and Peru filed objections to this rule.

Peru withdrew its objection in 1983. As a result of a bilateral agreement reached in 1984 between the United States and Japan, Japan agreed to withdraw its objection to the moratorium decision, effective as of 1988. Thus, the end of commercial whaling is within sight.

Status of Whale Stocks

The National Marine Fisheries Service (NMFS) reviewed the status of whale populations for the following species of "great whales" designated "endangered" according to the Endangered Species Act (ESA)[3,4]: blue whale (*Balaenoptera musculus*); bowhead whale (*Balaena mysticetus*); fin whale (*Balaenoptera physalus*); gray whale (*Eschrichtius robustus*); humpback whale (*Megaptera novaeangliae*); right whale (*Balaena glacialis*); and sei whale (*Balaenoptera borealis*). NMFS concluded that the condition of all of the above species, except the gray whale, continue to be so depleted that they should remain classified as "endangered" (Table 6–1). (See also Table 6–2.) The North Pacific stock of gray whales has recovered to historical levels, leading NMFS to conclude that its designation should be changed to "threatened" rather than endangered. NMFS has not yet completed its review of the sperm whale (*Physeter marocephalus*). The following discussion is taken from the species review papers compiled in a special edition of *Marine Fisheries Review* in 1984.

Bowhead Whale

Bowhead whales inhabited Arctic waters circumpolarly in four stocks — East Greenland-Spitsbergen, Davis Strait, Hudson Bay, and Western Arctic (Beaufort-Bering Seas). Worldwide population estimates prior to commercial exploitation are about 55,000 animals. Only the Western Arctic population survives today in more than a remnant population, numbering approximately 4,000, which is 20–25 percent of its initial population level.[5] This stock may have

TABLE 6-1. INITIAL (PRECOMMERCIAL WHALING) AND CURRENT POPULATION SIZE ESTIMATES OF LARGE WHALES. STOCK OR REGIONAL GROUP ESTIMATES ARE THOSE SUMMARIZED IN MARINE FISHERIES REVIEW 46(4): 7–64.

Species, Stocks, or Reporting Areas(s)	Population Sizes		Approximate Percent of Initial
	Initial	Current	
Gray whale			
Eastern North Pacific	15,000–20,000	13,450–19,210	Recovered
Western North Pacific	n.e.	n.e.[1]	n.e.
Blue whale			
North Atlantic	1,100–1,500	100	6–9%
North Pacific	4,900	1,400–1,900	29–39%
North Indian Ocean	n.e.	n.e.	n.e.
Antarctic[2]	150,000–210,000	1,000–8,000	<1.5%
Subantarctic Indian Ocean[3]	10,000	5,000	50%
Fin whale			
North Norway	Several thousand	n.e.	n.e.
West Norway/Faeroe Isl.	>2,700	n.e.[4]	10%?
Spain, Portugal, British Isles	>5,000	n.e.	n.e.
Denmark Strait	n.e.	1,791–11,584	n.e.
W. North Atlantic	n.e.	3,590–6,300	n.e.
North Pacific	42,000–45,000	14,620–18,630	32–44%
Antarctic[2]	400,000	85,200	21%
Sei whale			
North Atlantic	n.e.	4,957	n.e.
North Pacific	45,000	22,000–37,000	49–82%
Southern Hemisphere[2]	>63,100–64,400	>9,800–11,760	15–19%
Humpback whale			
E. North Atlantic	n.e.	n.e.	n.e.
W. North Atlantic	>4,400	5,257–6,289	Recovered?
North Indian Ocean	n.e.	n.e.	n.e.
North Pacific	15,000	<1,200	8%
Southern Hemisphere	100,000	2,500–3,000	2–3%
Bowhead whale			
E. Greenland -Spitsbergen	25,000	1	<%?
Davis Strait	22,000	n.e.[1]	<5%?
Hudson Bay	680	n.e.[4]	n.e.
Western Arctic	18,000	3,617–4,125	20–23%
Sea of Okhotsk	n.e.[5]	n.e.[4]	5–10%

(See footnotes at end of table).

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TABLE 6-1. INITIAL (PRECOMMERCIAL WHALING) AND CURRENT
—Continued POPULATION SIZE ESTIMATES OF LARGE WHALES. STOCK OR REGIONAL GROUP ESTIMATES ARE THOSE SUMMARIZED IN MARINE FISHERIES REVIEW 46(4): 7-64.

Species, Stocks, or Reporting Areas(s)	Population Sizes		Approximate Percent of Initial
	Initial	Current	
Right Whale[5]			
North Atlantic	n.e.	n.e.[4]	n.e.
North Pacific	n.e.	n.e.[4]	n.e.
Southern Hemisphere	n.e.	3,000?	n.e.
Sperm whale[7]			
North Atlantic	166,000	99,500	60%
Eastern North Pacific	311,000	274,000	88%
Western North Pacific	309,400	198,100	64%
Southern Hemisphere	509,600	410,700	70%

n.e. no published estimate

[1]Thought to be nearing extinction or extremely low.
[2]Six stock units of all oceans in the Southern Hemisphere.
[3]Pygmy blue whales.
[4]Perhaps in the low hundreds.
[5]Perhaps 6,500–10,000.
[6]Stocks are reported here by general area only. See Braham and Rice (1984) for stock boundaries.
[7]Exploitable population size, and includes males and females (from Tables 4–6 in Gosho et al., 1984(12)); No estimates are available for the number of immature animals.
All estimates of initial and current abundance are considered provisional.

Source: Braham, 1984(b)

increased somewhat since commercial whaling ended in 1911, but the magnitude of the increase is unknown. Alaska Eskimos continue to take about 22 bowheads per year. This is roughly the average annual native harvest during this century.

Right Whale

Right whales inhabit coastal temperate waters, which made them an easy target for whalers who heavily overexploited the species. Three small stocks remain — North Pacific, North Atlantic, and Southern Hemisphere. Data and sightings on northern hemisphere stocks are sparse. Although right whales have been protected since 1931, there has been little indication of recovery. However, stocks off the coasts of South Africa and Argentina appear to be increasing, although this increase is still small. The current world population is probably between 3,000 and 4,000 animals, which makes right whales the least abundant of the great whales and perhaps less than 5 percent of its pre-exploitation size.[6]

Blue Whale

Blue whales are the largest living animal, reaching to 100 feet. They migrate between polar and tropical waters. The North Pacific and North Atlantic

TABLE 6-2. A GENERALIZED EVALUATION OF THE POSSIBLE RECOVERY OF ENDANGERED WHALES BY STOCK(S) OF REGIONAL GROUPS.

STATUS
Perhaps recovered[1]
Eastern North Pacific gray whale
Western North Atlantic humpback whale
Status uncertain[2]
North Pacific sei whale
North Atlantic sperm whale(s)
North Pacific sperm whale(s)
Southern Hemisphere sperm whale
Depleted[3]
All stocks of blue whales
Davis Strait bowhead whale
Sea of Okhotsk bowhead whale
Western Arctic bowhead whale
North Pacific humpback whale(s)
Southern Hemisphere humpback whale(s)
Antarctic fin whale
North Pacific fin whale
Western North Atlantic fin whale
Western Norway/Faeroe Islands fin whale
Southern Hemisphere right whale(s)
Southern Hemisphere sei whale(s)
Nearing extinction
East Greenland-Spitsbergen bowhead whale
Western North Pacific gray whale
North Pacific right whale(s)
Insufficient data for judgment
Hudson Bay bowhead whale
Denmark Strait fin whale
North Norway fin whale
Spain-Portugal-British Isles fin whale
Eastern North Atlantic humpback whale
Northern Indian Ocean humpback whale
North Atlantic sei whale
North Atlantic right whale

[1]To estimated population size prior to commercial whaling.
[2]Possibly above or near 60 percent of estimated initial population size.
[3]Well below initial population size estimates, but may include low populations which have shown some increase (e.g., Southern Hemisphere right whales and western Arctic bowhead whale).

Source: Braham, 1984(b)

pre-exploitation stocks were much smaller than the Southern Hemisphere stock. Whalers overexploited all stocks. In 1967, the IWC imposed a worldwide ban on taking blue whales. There have been no recent systematic stock assessments.[7]

Fin Whale

Fin whales are the second largest of the whale species and are distributed from Arctic to tropical waters. They breed and migrate in open ocean areas, which makes it difficult to conduct a census. Although whaling for fin whales in the North Pacific and Southern Hemisphere ended during the 1970s, Aboriginal whaling off Greenland and commercial whaling off Spain continue. Adequate data do not exist to determine how quota reductions have affected fin whale populations in the Southern Hemisphere and North Pacific.[8]

Sei Whale

Sei whales are found over a wider range of temperate waters than other large baleen whales. Their feeding areas in all oceans are well-defined, but their migratory and winter/breeding areas are largely unknown. Harvests of sei whales increased in the North Pacific and Southern Hemisphere as populations of blue and fin whales declined; the IWC protected these stocks in 1975 and 1977, respectively. 1985 is the last year of North Atlantic sei whale harvests off of Iceland.[9]

Gray Whale

Gray whales once inhabited coastal waters throughout the North Atlantic and North Pacific Oceans. The North Atlantic stock was overexploited to extinction several centuries ago. The North Pacific population had two components — an eastern stock, which migrated along North America — and Korean stock, which migrated along the Asian coast. Both North Pacific stocks were heavily exploited, and by the beginning of this century, both stocks were very low. The Korean stock has not recovered and is possibly nearing extinction. Protected from commercial whaling since 1947, the eastern stock has recovered to nearly its initial population, which makes it one of the few whale stocks to recover from exploitation.[10]

Humpback Whale

Humpback whales, like gray whales, inhabit coastal waters throughout the world, which made them an easy-to-hunt prey for commercial whalers. In the North Atlantic, where the IWC banned commercial whaling in 1955, the western stock (North American) remains at very low levels (probably in the hundreds) although it appears to have recovered to nearly its original population. Very little current data are available on which to base an estimate of the eastern North Atlantic stock. The Southern Hemisphere stocks, protected since 1966, show little evidence of recovery from intensive commercial whaling. The only known humpback whaling currently conducted and reported to the IWC is by native Greenlanders, who take about 10 humpbacks annually.[11]

Sperm Whale

Sperm whales inhabit all oceans of the world, usually remaining in offshore waters. Whalers hunted sperm whales for their spermaceti oil, which is an excellent lubricant, rather than for their blubber-reduced oil, which is of poorer quality than oil from baleen species. Exploitation of sperm whales increased dramatically during the 1950s, reaching a peak of 29,000 whales in 1964. IWC-imposed quotas have lowered their level; today only a small level of sperm whaling continues by Japan (about 400 whales in 1984). On the Portugese Azores less than 20 whales annually have been taken in recent years. In 1981, the IWC established a zero quota for sperm whales worldwide to become effective after 1983. However, Japan filed an objection to this catch limit and Portugal is not a member of the IWC.

The best estimates of pre-exploitation and current sperm whale populations rely on a variety of stock assessment methods, whose accuracy continues to be debated. Nevertheless, estimates of the North Atlantic, eastern and western North Pacific, and Southern Hemisphere stocks of sperm whales indicate these stocks to be at least 60 percent of their original population levels, which suggests limited recovery from commercial whaling.[12]

The U.S.-Japanese Bilateral Agreement

At its July 1982 meeting, the IWC adopted the following change to its Schedule (the rules of the Commission):

> Notwithstanding the other provisions of paragraph 10, catch limits for the killing for commercial purposes of whales from all stocks for the 1986 coastal and the 1985/86 pelagic seasons and thereafter shall be zero.

The vote was 27 nations in favor, 7 opposed, and 5 abstentions. The IWC had voted to impose a moratorium on commercial whaling, which signaled the culmination of a decade-long worldwide whale conservation effort.

However, under the terms of the International Convention for the Regulation of Whaling, member nations may file an objection to IWC decisions and not be obligated to comply with any Schedule change to which it objects. Japan, U.S.S.R., Norway, and Peru filed objections to the whaling moratorium decision.

The IWC has no authority to penalize member nations that fail to abide by its rules. Nations file infraction reports on harvests, but the IWC cannot impose fines or sanctions. However, two U.S. laws — the Pelly Amendment to the Fishermen's Protective Act and the Packwood-Magnuson Amendment to the Magnuson Fishery Conservation and Management Act — require the U.S. to impose certain sanctions against nations that diminish the effectiveness of international conservation treaties. Under the Pelly Amendment, the U.S. can embargo imports of fishery products from countries whose nationals are certified by the Secretary of Commerce as conducting fishing (including whaling) operations that diminish the effectiveness of conservation programs like the IWC's. If a nation is certified by the Secretary of Commerce, the Packwood-Magnuson Amendment mandates the Secretary of State to reduce, by at least 50 percent, the allocation of fish that may be caught by any certified nation

in the U.S. Fishery Conservation Zone. These laws provide a formidable deterrent to nations that fish within the U.S. Fishery Conservation Zone or export fishery products to the U.S.

Negotiations and Agreement

As matters stood in November 1984, Japan had filed two formal objections to separate provisions of the IWC Schedule. The first of those provisions, originally made in 1981, prohibited whaling on the Western Division of the North Pacific stock of sperm whales at the end of the 1983 coastal whaling season. The second was the "moratorium" on all commercial whaling. The moratorium will apply to pelagic whaling beginning in the fall of 1985 and to coastal whaling in 1986.

The Convention permits objections, like Japan's; thus, Japan, having filed its objections, would not be in violation of the Convention, even if it continued to whale. To put it another way, Japan's coastal sperm whaling in 1984 was subject to no international quotas, just as all Japanese commercial whaling after the effective date of the moratorium would not have been subject to international quotas, as long as Japan maintained its objection to the moratorium. However, the Pelly and Packwood-Magnuson Amendments require the United States to consider sanctions against any country whose actions diminish the effectiveness of the IWC, even if the foreign country is acting within the procedures established by the Convention. The U.S. reviews these activities on a case-by-case basis.

After difficult and detailed discussions during November 1984, the Charge d'Affaires *ad interim* of Japan sent Secretary of Commerce Malcolm Baldrige a letter proposing conditions under which Japan would withdraw its objections and comply belatedly with all aspects of the IWC conservation[13] Secretary Baldrige's reply concluded that if Japan took the steps set out in its letter to comply with the IWC sperm whale and moratorium decisions, Commerce would no longer view Japan's actions as diminishing the effectiveness of the IWC conservation program and thus Commerce would not certify Japan under the above laws.[14]

Specifically, the arrangement provided that if the Japanese agreed to end all commercial sperm whaling, effective at the end of the 1987 coastal season, then the Japanese could take up to 400 sperm whales during each of the 1984 and 1985 coastal seasons without risk of U.S. sanctions. On or before December 13, 1984, the Japanese were required to withdraw their objection to the end of sperm whaling and to cease its whaling by 1988. Japan withdrew its objection on December 11. The second part of the November arrangement, under which Commerce agreed not to impose Pelly or Packwood-Magnuson sanctions, required Japan, by April 1, 1985, to withdraw its moratorium. In return, the Japanese may take up to 200 sperm whales in each of the 1986 and 1987 coastal seasons and may take other whales under limitations acceptable to the United States through the end of the 1986/87 pelagic season and the end of the 1987 coastal season.

Decision Challenged

Several environmental groups sued the Secretaries of Commerce and State to prevent Secretary Baldrige from carrying out his agreement with the Japanese

and to force him to certify the Japanese for exceeding the zero quota on sperm whales in 1984. They argued that under the Packwood-Magnuson and Pelly Amendments the Secretary had no discretion with regard to certification.

On March 5, 1985, Judge Richey of the D.C. District Court granted the environmental groups' motion for summary judgment and ordered Secretary Baldrige to certify to the President, under the Packwood-Magnuson and Pelly Amendments, Japanese sperm whaling in the 1984 coastal season.[15] As a result of this decision, the Japanese informed Secretary Baldrige on April 5, 1985 that they would remove their objection to the IWC moratorium decision and abide by the agreement as stated in the November 1984 exchange of letters within five days of a Court of Appeals decision upholding the U.S. Government's agreement with Japan.[16]

The United States appealed, and on March 18, 1985, the Court of Appeals granted a stay pending appeal and established an expedited schedule for briefing and oral agrument, which was held on May 16, 1985.

Regardless of the outcome of this litigation, commercial whaling throughout the world is coming to an end.

Fish and Wildlife Protection and Management

Endangered and Threatened Species

The Fish and Wildlife Service (FWS) in the U.S. Department of the Interior is the principal agency responsible for implementing the Endangered Species Act of 1973. However, under specific provisions of that Act, the National Marine Fisheries Service in the U.S. Department of Commerce is responsible for some species of marine mammals (whales and seals); and the Animal and Plant Health Inspection Service in the U.S. Department of Agriculture is responsible for enforcing port-related import/export regulations for plant species listed in Appendices of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). FWS is responsible for other marine mammals (sea otters, manatees, and dugongs), for wildlife listed under CITES, and for all nonport-related endangered plant regulations.

During 1984, 46 new species were added to the U.S. List of Endangered and Threatened Species, bringing the total listed to 828 at the end of the year, including 331 native and 497 foreign species. FWS also published the last of three notices for review of native candidate species. Over 2,000 native U.S. species have been identified as candidates for eventual listing. Such periodically updated notices of plant, vertebrate, and invertebrate species under consideration both inform the public about anticipated listings and solicit additional information upon which to base listing decisions. Rather than proceeding on one species at a time, endangered ecosystems are treated as units, in which constituent species are surveyed and listed together. This strategy reflects a trend towards protecting those ecosystems upon which endangered and threatened species depend.

FWS has also continued to plan for and implement the protection and recovery of listed species. In 1984, 54 new recovery plans were approved for listing species, bringing the total of such plans to 164. These plans now cover 56 percent of listed species.

In recent years, the trend in Section 7 consultations under the Endangered Species Act has been for earlier and more informal consultations between the FWS and development agencies. Instances of protracted conflicts have been reduced by consulting in the early stages of project planning, development, and construction.

Over the past five years, 25,285 informal and 3,101 formal consultations have been held, of which 229 resulted in "jeopardy" opinions. Overall, less than 8 percent of all consultations have resulted in "jeopardy" decisions. In 1984, over 8,000 formal and informal consultations were conducted to assist the efforts of federal agencies to comply with the Act. Twenty-three of these 1984 consultations resulted in "jeopardy" opinions, which held that certain aspects of particular projects would jeopardize the continued existence of an endangered species.

Some Good News

In 1984, the *brown pelican* became the first endangered species to recover to the extent that it could be removed from the federal endangered species list. The removal covers brown pelicans in Alabama, Florida, Georgia, North and South Carolina, and points northward along the Atlantic Coast. The pelican's recovery in the East is attributable largely to the diminishing effects of DDT and other pesticides that reduced the bird's reproductive ability during the 1950s and 1960s. Federal, state, and private efforts to protect pelican nesting colonies also contributed to the species' recovery.

The nation's symbol, the *bald eagle*, continued its recovery during 1984. For the past three years, the DuPont Company has supported an FWS captive-breeding program for eagles, which has enabled the Service to expand its eagle breeding facilities and increase the number of eagle pairs in captivity. In 1984, a record 18 eaglets were raised in the innovative captive breeding program at the Patuxent Wildlife Research Center near Laurel, Maryland.

The eaglets were released in New Jersey, Pennsylvania, Ohio, Tennessee, Georgia, and — for the first time — in North Carolina. In previous years, eaglets were also released in New York, Maine, Delaware, and Virginia. A total of 71 eaglets from Patuxent have been released to the wild since 1976. By supplementing the natural population of bald eagles in the lower 48 states with young eaglets produced in captivity or relocated from Canada, researchers hope to speed the species' recovery in areas where its numbers still remain low. About 5,000 to 6,000 bald eagles, including about 1,500 breeding pairs, live in the lower 48 states year-round.

The encouraging progress made during 1984 in the recovery of the endangered *California condor* has been tempered by subsequent events. Scientists sought to foster increased production and survival of condor chicks by removing eggs from nests and incubating them at the San Diego Zoo. Removal of the eggs stimulated the wild condors to produce new eggs, thus increasing the natural rate of reproduction.

All told, five wild condor pairs — including a pair newly discovered by observers this year — produced a total of seven healthy young in 1984, about three times as many chicks as could have been expected normally. Six of the chicks were hatched at the zoo; the seventh, hatched in the wild, was taken

into captivity in September with the permission of the State of California. That brought the number of California condors in captivity to 16 — 10 females and six males. The 1984 breeding success and increase in the captive population are particularly important in view of the apparent loss early in 1985 of several condors from the wild population early in 1985. Scientists from the recovery program captured four wild condors and outfitted them with radio transmitters so that observation and tracking of the wild population can continue.

FWS and the states of Maryland and Delaware reintroduced a population of the endangered *Delmarva fox squirrel* to Sussex County, Delaware. This was the first reintroduction of an endangered species under regulations completed by FWS in 1984, providing for the designation of "experimental populations" of listed species.

National Species of Special Emphasis

As part of an effort to establish a national framework for wildlife resource management planning, FWS established a national Important Resource Problem (IRP) system for prioritizing critical resource issues.[17] This system was an important step toward the development of a coordinated resource planning process, called Regional Resource Planning (RRP), involving all regions of the country.

The RRP process involves an initial resource analysis to determine the status of selected species, called "species of special emphasis." The information from the resource analysis phase is used to establish national objectives and to identify potential difficulties that may impede their achievement. Specific management strategies are then developed, evaluated, and selected for achieving each objective. Some 859 species of special emphasis were initially identified following the completion of resource analysis efforts.

The initial list was narrowed to 46 National Species of Special Emphasis (NSSE) with one additional species added after public review. Five more NSSEs and one species group (Great Lakes percidae) were added in 1984. Specific management plans were developed for each species, and some species were further divided into discrete management populations (for example, Canada goose populations in the Atlantic Flyway). Selection as an NSSE species was based upon several criteria such as: population status and threats; conflicts in use or demand among user or administrative groups; degree of public interest; and economic value. The selection of NSSE, which are the focus of the Regional Resource Plans, serves to identify priority wildlife management needs on a national scale and to focus and coordinate FWS planning efforts.[18]

In 1984, management plans were drafted for 51 migratory bird populations involving 22 species that have been designated as NSSEs. Examples of other specific management actions taken for NSSEs include: establishment of harvest restrictions for black ducks and a public information program to inform hunters of the need for reducing the take of this declining species; extensive field work to provide data for evaluating stabilized duck hunting regulations in the U.S. and Canada; establishment of a clearinghouse for literature pertaining to lead poisoning of waterfowl; and FWS release of over 300 captive-bred endangered peregrine falcons in various locations around the U.S.

Sport Fisheries Management: State Role Expanded

The Federal Aid in Sport Fish Restoration Act, commonly known as the Dingell-Johnson Act, was amended on July 18, 1984, as part of the Deficit Reduction Act of 1984 (Public Law 98–369). The new legislation established the Wallop-Breaux Aquatic Resources Trust Fund, to be funded by motorboat fuel tax collections and duties on imported sport fishing equipment, yachts, and pleasure craft, and the imposition of an 11 percent manufacturer's excise tax on an expanded list of fishing tackle items. As of October 1, 1984, revenues collected by the Internal Revenue Service and U.S. Customs Service were deposited into this account.

With these funds, state sport fish programs can expand their program for recreational anglers. Several provisions in the new law condition the use of these new funds. For example:

- Coastal states must allocate funds equitably between marine and freshwater activities in accordance with the proportion of resident saltwater and freshwater anglers in that state;
- States may use up to 10 percent of their apportionment to establish and fund an aquatic resources education program;
- States must use at least 10 percent of their annual apportionment for boating access facilities; and
- States are authorized to use grant funds prospectively in multi-year acquisition or construction projects.

Other notable provisions include designating one-third of 1 percent of the funds collected to the District of Columbia for sport fish management, and reducing from 8 percent to 6 percent the amount that the federal FWS may deduct for program administration.

FWS's Fishery Resource Program: Federal Role Refocused

During 1984, a final working draft was completed of a Statement of Responsibilities and Role of the Fishery Resource Program. The statement describes and explains the basis for the desired focus of FWS's contribution to the stewardship of the nation's fishery resources.

Identification of program responsibilities was based on examination of statutory mandates, assessment of interjurisdictional or transboundary (international, interstate, tribal/state, migratory) resource needs, resource allocation issues, and shared responsibilities. After this review, four areas were identified as representing bonafide national responsibilities meriting the highest priority attention of the FWS's Fishery Resource Program. These are:

- Facilitate restoration of depleted, nationally significant fishery resources;
- Seek and provide for mitigation of fishery resource impairment due to federal water-related development;
- Assist with management of fishery resources on federal (primarily Service) and Indian lands; and,
- Maintain a federal leadership role in scientifically based management of national fishery resources.

By focusing its attention on a limited number of important fishery problems with national dimension, the FWS can use its manpower and funding more

efficiently and thus more quickly attain major program objectives. As a result of closer cooperation with states, tribes, and others in advancing the best interests not only of the fishery resources themselves, but also of those who use them, the expected result of this refocused federal effort will be increased quality of the nation's fishery conservation effort and increased quality of fishing opportunities.

Private and Voluntary Efforts

The 50th anniversary of the Federal Migratory Bird Hunting and Conservation Stamp program was commemorated in 1984. Sale of the popular "Duck Stamps" to waterfowl hunters, conservationists, and stamp collectors provides funds for acquisition of vital wildlife habitats for the National Wildlife Refuge System. More than 40 national corporations, retail merchandisers, and conservation organizations joined FWS and Ducks Unlimited, Inc., in encouraging broader suppport for this unique conservation revenue vehicle. The 1984 anniversary year was highlighted by a Presidential proclamation and a Congressional resolution on behalf of the Duck Stamp and by the issuance of a commemorative postage stamp by the U.S. Postal Service.

As 1984 began, FWS had more than doubled the level of participation in its volunteer program over the previous year, from over 4,000 individuals nationwide to more than 8,600. The time that these public-spirited citizens contributed to the agency's national wildlife refuges, fish hatcheries, and research laboratories tripled during the same period; during 1984 this figure increased to 11,447 volunteers who contributed 527,150 hours of work — a 33 percent increase over 1983, signifying the opening of further opportunities for private citizens to make tangible contributions to national fish and wildlife conservation programs.

A number of national corporations also made significant donations or other contributions to the work of FWS in 1984, among them are the following:

- DuPont de Nemours Company
- Tenneco Oil Exploration and Production
- Prudential Insurance Company of America
- American Telephone and Telegraph Company
- International Mineral and Chemical Corporation
- Deere and Company
- Agrico Chemical

On March 26, 1984, the President signed legislation to create a National Fish and Wildlife Foundation. This federally chartered, nonprofit corporation establishes a mechanism by which gifts of real estate and personal property can be made to the federal government for fish and wildlife conservation purposes. A nine-member board of directors supervises the work of the National Fish and Wildlife Foundation, which was officially instituted in January 1985.

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Chapter 7

Water Resources for Power, Transportation, Irrigation, and Development

Federal participation in the development of America's water resources dates to the term of President James Monroe. In 1824, Congress gave the U.S. Army Corps of Engineers $75,000 to remove a number of sandbars in the Ohio and Mississippi Rivers to improve navigability. The work sought to encourage travel westward.

Gradually Congress thrust new water responsibilities onto agencies of the federal government. The Reclamation Act of 1902 gave the Department of the Interior the task of developing irrigation water to make the arid West bloom. The Corps of Engineers assumed the task of developing hydroelectric power in 1912. In 1917 the Corps received $45 million to pay for new responsibilities over flood control. Inexorably the federal mission expanded: beach erosion control, urban water supply, hurricane protection, aquatic weed control, small watershed protection.

Federal water development reached a peak during the 1930s with the construction, among many projects, of Hoover Dam on the Colorado River and a series of navigation locks to stair-step barge traffic up the Mississippi River to Minneapolis. Another peak in construction activity came during the 1950s and 1960s, when major dams and waterway transportation systems were added through much of the West, up the Arkansas River, and throughout the South. These peaks in federal project construction were probably more attributable to attempts to "counter" unemployment during business cycle downturns than they were to asserting additional federal responsibility for water resources development. The famous Pick-Sloan comprehensive water resources development plan for the Missouri River Basin, authorized in 1944, was viewed as a public works project to create civilian employment opportunities in the wake of the demobilization of the military following World War II.

By 1985 the water project spending by the Corps of Engineers, the Department of the Interior's Bureau of Reclamation, and the Department of Agriculture's Soil Conservation Service reached $4.3 billion. Collectively, these agencies operated 850 major dams, 25,000 miles of inland waterways, and 240 navigation locks. They dredge 200 commercial harbors, generate about 6 percent of the nation's electricity, and provide 11 million acres of cropland and pasture with 40 million acre-feet of irrigation water. (An acre-foot of water is the volume needed to cover an acre of land with water to a depth of one foot, or 325,851 gallons.) These agencies also supply 10 million acre-feet of water to cities and industries, and monitor 3,400 miles of flood control levees.[1]

The justification for federal participation grew from the interstate character of most river basins; water, after all, is a "moving, wandering thing." Because

this assumption of responsibility was to be "federal," nearly all work was undertaken at the expense of the federal government. When there was non-federal participation in the cost of a federal water project, it was to provide the land for the project, to promise to operate the project following completion, or to agree to buy products from the project, such as electricity, irrigation water, or municipal water.

Has this system served America well? Will it continue to serve America well? Or has it led to shortages and distorted patterns of water use by exaggerating water "needs"?

This chapter attempts to address these questions. It will review the current status and likely future trends in American water development. It will show how the federal program has declined over the past two decades, decreasing the likelihood that federal construction will supply the perceived need for "more" water. This chapter also identifies ways by which the federal government might move toward a more effective water resources policy, simply by withdrawing closer to the periphery of the issue. It concludes by documenting a broad array of promising approaches that have resulted from placing greater reliance on the initiative and resources of states, municipalities, and the private sector.

Water: The Latest "Crisis"?

When the word "water" is mentioned in a national context, it often comes hitched to the word "crisis." The press, academicians, and politicians regularly proclaim that water is America's next great natural resources crisis. "Our Nation's water resources are steadily and very rapidly becoming inadequate and unusable," one Senator recently told the Senate.[2] The House of Representatives twice in 1984 passed legislation containing some $20 billion in what one of its members termed "badly needed" new water development projects.[3] Testimony before Congress regularly cites the vast "need" for construction of more water projects.[4]

By spring of 1985, reports of a potential drought in the Northeast had begun to creep onto the front page of major newpapers. Rainfall in Washington, D.C., was a third below normal rates.[5] The Catskills watershed serving New York City received so little precipitation following the summer of 1984 that by the spring of 1985 city reservoirs held only 59 percent of their capacity — far less than the 96 percent of capacity typical at that time of the year.[6] By July 1985 New York City was pumping drinking water from the Hudson River for the first time in 18 years.[7]

The Second National Water Assessment of the Federal Water Resources Council found in 1977 that water consumption had doubled over 20 years and projected that 17 of the nation's 106 hydrologic regions could expect to have serious water problems by the end of the century. It concluded that the entire nation west of the Mississipi could expect to run short of water by the year 2000.[8] We all are simply running out of water, the argument goes.[9]

Is this true? Are we facing a "crisis" in water? And, if so, what should America do? One representative of an organization of state water resources agencies set the cost at $500 billion to meet America's water resources "needs."[10] If it is a crisis, is the single answer more development, or at least more federal development, at a cost to the taxpayers of half a trillion dollars?

A broad examination of the issue demonstrates that:

1. In the absence of federal funding, non-federal groups, both public and private, have assumed responsibility for priority work and in the process have demonstrated remarkable ingenuity, often achieving significant cost savings to the economy; and
2. When water rights and preferred access to publicly supplied water and water-based services have been recognized as negotiable private property, a freer market can function. More marketplace competition to determine the use and price of water can alleviate much, if not all, of the "need" for extensive new project development.

COST-SHARING AND LOCAL INITIATIVES

A variety of recent events seem to have altered the course of federal water development and to have decreased significantly the federal role. These events have moved much of the nation's water development out of federal hands and into those of state and local agencies.

One major environmental group notes: "As competition for water. . . intensifies and the costs of providing water when and where it is needed rise, water policy has entered a period of fundamental change, marking a shift from an era of water development to one of water management."[11] There has been a prolonged and sharp decline in the level of federal participation in the construction of new water projects. At a time of increasing budget deficits and an expanding commitment to other types of federal acitivity, including a major water pollution cleanup program, traditional water development simply became an easy program to clip back.

After eliminating the effect of inflation, federal funds spent on Corps of Engineers construction work have dropped 78 percent since the mid-1960s.[12] One result has been a dramatic increase in the backlog of unfinished federal work. By the end of fiscal year 1986, there will be 911 Corps projects, authorized by law, that will be either unfinished or not yet started. The cost to complete these 911 projects is $28.3 billion.[13] At current spending levels, that backlog would keep the Corps busy until the year 2015, assuming that not a single additional project is authorized over the next 30 years.

This slowdown in spending, together with various procedural and regulatory hurdles, has lengthened the time needed to build a project. It now takes 26 years from the time the Corps of Engineers identifies a water resources problem until construction begins on a solution to the problem.[14] For flood control projects, that span is even longer — 29.4 years. Extensive delays also occur at the Bureau of Reclamation.

It is sometimes argued that this decline in federal activity has been a natural evolution: the nation simply has run out of environmentally acceptable sites for large-scale new water resources projects. However, equally compelling explanations include the severe competition for federal dollars, at a time when no priority system exists to assure with any certainty the need for the federal project.

Despite the gradual drying up of money for water projects, many non-federal groups continue to plead for federal funds, while resisting any reform in the way in which those projects are financed. Federally financed construction,

however costly, is often seen as more attractive than non-federal construction or any improved efficiencies through improved operations at non-federal expense.

"Many non-federal entities do not have the ability to generate sufficient front-end funds," one group argues. "Upfront financing of federal projects by non-federal sponsors should, therefore, be opposed except in those circumstances where it may be preferred by the non-Federal sponsor."[15]

Despite protests, shifts have begun to occur outside the federal government toward more rapid development, often in ways more effective than appear to be achievable by the federal government.

Besides the reality of a declining federal presence, much of the attraction to non-federal officials is the desire to avoid federal red tape and regulations, and the fear that new cost-sharing guidelines would require them to pay a larger portion of costly federal overhead. The following examples illustrate this trend:

- In 1966, the Corps of Engineers built a harbor breakwater at Eastport, Maine. Due to the wear and tear of nature, the breakwater had begun to deteriorate by the early 1980s. The town of Eastport asked the Corps to rehabilitate the breakwater. The Corps estimated the cost at $2.5 million, but told town officials the project held such a low priority that it would probably take the Corps a decade to get to it. Seeking an alternative, local officials persuaded Congress to deauthorize the breakwater as a federal project in 1983 (Public Law 98–181); they put together a package of funds to rehabilitate the breakwater and constructed a new 420-by-40-foot pier alongside the breakwater. The town also dredged the harbor off the pier to a depth of 40 feet, then used the dredged material to lengthen the runway of the local airport and to fill in some marshy areas adjacent to a local elementary school. The result is a harbor that now accommodates ships with a depth of 40 feet (instead of 22 feet, a change that has quintupled traffic at the port), an improved airport, and an improved schoolyard. It occurred a decade ahead of schedule. The total cost: $3.5 million.
- A hydropower project in Alaska known as Bradley Lake was authorized for construction by the Corps of Engineers in 1962. Like many others, this project languished. Following discussions between the state of Alaska and the Corps, the state asked that the federal project be deauthorized. This occurred in Public Law 97–377. Since then, the state of Alaska has passed legislation scheduling appropriations of $218 million for its own Bradley Lake project and plans to sell bonds to cover the remaining $135 million needed to complete a dam producing 90 megawatts of power for the Alaska Railbelt area. Final design work was to begin in June 1985. The necessary license from the Federal Energy Regulatory Commission is anticipated by December 1985. Site preparation work is expected to begin in the summer of 1986, with full construction work to begin in 1987. The state of Alaska anticipates that power will be on line by late 1989. Under the optimum schedule outlined by the Corps of Engineers, the project would have taken seven years to construct.
- Some harbor authorities appear ready to move on their own, not waiting for the tedious federal process. The Port Authority of New York and New Jersey, seeking a $200 million federal channel-deepening project, may soon turn to private financing for funds to dredge the port. The fear is that

unless the port gains at least five feet of depth — five feet of greater efficiency — much of the port's profitable container traffic will move elsewhere.

- Utah considered an on-its-own construction of the Little Dell Dam, an authorized Corps flood control project near Salt Lake City. A state-financed project of a somewhat smaller scale, state officials calculate, would cost the people of Utah less than a federal project that would require them to pay only 35 percent.
- In 1981, New Jersey voters approved a $350 million bond issue for rehabilitation and construction of water supply facilities.
- Under a 1983 North Carolina law, 40 percent of the revenue from a new local option sales tax will be devoted to water or watershed projects.
- In 1982, the Massachusetts legislature established $333 million in new bonding authority for water system rehabilitation and water quality protection.
- In 1983, Nebraska passed legislation to establish a program to finance the development of ground-water recharge reservoirs, using pumping fees to retire revenue bonds.
- Arizona and Minnesota recently established task forces to find new ways of providing water project funding.[16]
- The state of Wyoming has created its own water project development fund, using mineral severance taxes, then pledged $47 million to pay nearly half the cost of the Buffalo Bill Dam project.[17]
- Texas voters this November will consider a $980-million state bond issue for new water development projects.
- The Colorado Legislature considered an increase in the state sales tax to be dedicated to the construction of new water projects.
- Nevada taxpayers are expected to spend $22 million on a dam on the South Fork of the Humboldt River near Elko, work that the Corps had been studying for a number of years. Local project design work was financed by an entertainment tax in Elko.
- Utah is also developing its own $96 million program of dikes and dredging to control the level of the Great Salt Lake. While these activities normally fall within the responsibility of the Corps of Engineers, Utah officials say they are unlikely to await federal action.
- Even on federal projects, non-federal agencies appear to recognize the need to contribute more. Sponsors of 23 Corps of Engineers non-navigation projects have agreed informally with the Corps to contribute higher than normal non-federal shares to get their projects moving. The total construction cost on these 23 projects listed in the President's fiscal year 1986 budget is $961.8 million. Using traditional cost-sharing rules, non-federal sponsors would have to contribute $154.5 million in lands and similar costs. Under the new arrangements, the non-federal costs in lands and cash would total $495.4 million.

WATER PRICES, WATER MARKETS, AND "NEW" WATER SUPPLIES

As spending on the federal program declines, encouraging other public and private agencies to fund their own projects, there are even more significant

developments in the marketplace and in the courts. These actions may alter further the way water is allocated and used, particularly in the more arid western states. This shift toward greater reliance on the market could go far toward reducing dramatically the need for future spending, either federal or non-federal. One water utility executive may have stated the situation best: "We are not running out of water, we are running out of cheap water."[18]

One short-term "solution" for thirsty cities and farms has been to meet growing water needs by developing new underground sources of water, sources often outside state regulation of surface waters.

> "In 1970, 19 percent of the water used in the United States came from groundwater sources. By 1980, reliance on groundwater had grown to 25 percent, and it is expected to continue growing. The West has become particularly dependent on groundwater use, where it accounts for 46 percent of municipal and 44 percent of industrial water supplies.
>
> Technology has also been influential in determining use rates. The development of sprinkler irrigation, for example, caused a three-fold increase in groundwater withdrawals between 1950 and 1975 in the West. Today, these withdrawals account for 39 percent of all Western irrigation water used. The increase in groundwater use might not be so worrisome if withdrawals from groundwater basins did not exceed natural recharge."[19]

Annual withdrawals from Western aquifers now exceed recharge by more than 22 million acre-feet; that volume is 50 percent greater than the annual flow of the Colorado River.[20]

The focus of the problem of ground water depletion has been the Ogallala Aquifer, a formation of permeable soils, rather like a tub filled with coarse sand that has been saturated with water. Natural recharge from rain and rivers flows into the "tub," while water is being pumped out. If the flow into the tub matches the pumping rate, the level of saturation remains stable. Once pumping exceeds the recharge, the level of saturation declines.

The Ogallala provides a classic example of the perverse incentives that come into play in managing common property resources. This aquifer is the nation's largest underground source of water, and provides water to eight states of the High Plains area: Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming. Three decades ago, water was pumped from 2,000 wells in the Ogallala. Because the aquifer has been treated as a common property resource with no effective legal or economic rationing, heavy pumping from as many as 70,000 wells now drilled into the Ogallala has lowered the water table more rapidly than rainfall can replenish it.

Water levels have fallen more than 100 feet in portions of Kansas, New Mexico, Oklahoma, and Texas.[21] The volume of water remaining in the Texas portions of the Ogallala is projected by 1990 to drop 30 percent from 1977 levels.[22]

What is the response? The Bureau of Reclamation found that after the cost of extracting water had risen from $3 per acre-foot to $10 per acre-foot, the efficiency in the use of that water by farmers had jumped from less than 44 percent to more than 60 percent. As the cost of water rose, farmers used it more efficiently.[23]

A few states, including Arizona, Mississippi, New Jersey, New Mexico, and

Utah have confronted aquifer depletions by limiting development, using the concept of a closed ground-water basin. This is a first step toward recognizing the property rights in ground water: setting boundaries, recognizing limitations on yields, and restricting access to the common aquifer.

In addition, ground-water recharge activities have been initiated by several states, including Arizona, California, Colorado, Nebraska, and Idaho, with federal activities limited primarily to research and modeling of ground-water hydrology, and demonstrations of actual recharge.

In its 1983 Annual Report, the Philadelphia Suburban Corp. offered these observations:

> "Because water appears to be so plentiful, it has been taken for granted and consequently has been wasted and abused. Further, the many problems that have crept up on us have literally been out of sight and out of mind. People cannot see leaking, corroding water mains or deteriorating, declining water tables. And it is consistent with human nature that we inherently resist paying for a solution to an invisible problem.
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> "As a result, we have constantly priced water at a level that demeans its true value, while allowing our nation's water problems to approach crisis proportions. . . . Consumers are used to low water rates and have based their use of water on the rates they pay. . . . There is a price to ensure an adequate supply of water to meet growing and diverse demands. But who pays the price?"[24]

A refusal by the federal government to intrude further into the process of allocating water resources, permitting market forces to take a stronger role in setting priorities, will almost certainly augment the water available for higher-value uses, including both urban and industrial uses and higher-value crops.

Price will play a key role in this reallocation. In the past, costs have not always been reflected in the price charged to users of federal waters. However, as water rights and access rights to publicly supplied water and water-based services become marketable, price changes increasingly will provide incentives to assure that water moves to its highest-value use. As one environmental group noted:

> ". . . Such reforms encompass a set of effective and as yet largely untapped approaches to increasing the efficiency of the use and allocation of the State's precious water resources.
>
> "From an economic perspective, any attempt to increase the efficiency of the State's usage and allocation of its water supplies ought to include three critical elements: (1) the use of free-market principles; (2) a commitment to cost-effective public investment; and (3) the implementation of a price structure which provides accurate signals to consumers regarding the relative scarcity of the resource.
>
> "The first element, that of free-market principles, refers mainly to the use of competitive markets for the transfer of water from willing sellers to willing buyers. If properly executed, such transfers may result in economic benefits to both parties. . . ."[25]

Changes in pricing of water also affect the way it is used:

"Users can only afford to be wasteful when water is cheap. In agriculture, if water carried a higher price, it is likely that less water would be applied to any given crop, that different irrigation technology or water application practices would be used, and that different cropping patterns might appear."[26]

Evidence shows that efficient use requires that water be priced in line with market realities. A classic example involves New York City. In the spring of 1985, residents of New York faced a potential drought. Yet New York City water users confronted no real controls on excessive use; water is not metered. Thus, a householder pays the same price for water service if he uses a cupful of water or if he waters his lawn 24 hours a day. Despite past water shortages, New York has never seriously considered modifying its pricing policies for water, which had been revised once (in 1932) from a schedule set in 1896.[27] Instead, in drought periods, New York City carried out a vigorous water conservation campaign. During one drought period, residents cut per capita daily water use from 85 to 60 gallons. Exhortations have some effect; their limitation is indicated by the fact that during the same period, daily water consumption in Detroit, which had universal metering but no conservation campaign, was only 49.5 gallons per capita.[28]

Greater flexibility in the pricing and sales of water would almost certainly relieve most "shortages" that exist. This is true for New York City, but also for more arid areas of the nation.

In the East and Midwest, water use is determined by what is known as "riparian doctrine" from English common law. This provides that owners of land abutting a stream have equal rights to the use of that water.

By contrast, the use of water in Western states is governed by variations on the doctrine of "prior appropriation," which allocates water on the basis of "first in time, first in right." The farmer or the municipality that first uses water from a particular body of water continues to hold the right to use that volume of water, as long as it is used "beneficially." In a year of drought, the older, more senior "water rights" take precedence over newer ones. Within limits, often very constricting ones, these property rights to water can be traded or sold, as long as the water remains in "beneficial" use, a term that favors extraction over conservation.

Although this system of water rights has served the West well in the past, it has tended to protect the status quo by retarding innovative changes in water-use patterns that might "expand" the amount of water available. Existing California statutes, for example, preclude a transfer of water outside an irrigation district, even though such a transfer might prove advantageous both to the farmer-seller and to the urban-buyer. What appears to be a shortage of water "is actually the manifestation of restrictions on water rights transfer."[29]

Thus, if greater freedom were allowed in a water market, the existing system of water rights would offer vast reservoirs of "new" water for development, plus income to many holders of existing water rights.

This "creation" of more water from existing sources is often superior to meeting demands for water by the construction of new projects. Under such market strategies, "more water will have to be squeezed out of existing

supplies by conservation, better management, and, in some cases, transfers from present users."[30]

Market reallocations of water can be dramatic. Over the past 20 years, the value of water rights held by farmers in the Denver area has risen to $280 an acre-foot from about $4. "No crops grown in Colorado's front range have high enough values to be able to afford this cost. These prices are due to municipal demands for water and agricultural expectations of continued water price increases."[31] If such sales are allowed, of course, they would benefit the buyer as well as the seller.

The Case of the Metropolitan Water District

One of the best examples of the opportunities that could be available with greater market freedom involves the options confronting the Metropolitan Water District, an independent agency that sells water wholesale to cities and smaller water districts in Southern California.[32]

The city of Los Angeles, through the district, has been discussing new partnerships with the agricultural users of federal water in the Imperial Valley of California. By one calculation, Los Angeles could obtain 400,000 acre-feet of "new" water annually if farmers in the Imperial Valley of California undertook several steps toward water conservation: lining canals with concrete, building new systems to recover seepage, and expanding electronic controls.

However, such work is relatively expensive. These conservation investments might cost $20 to $170 per acre-foot, compared with the $10 per acre-foot that Imperial Valley irrigators now pay for water.[33] Since this work would not increase farm productivity, no incentive exists for the farmer to pay for this work, particularly under rules where the farmer must "use" the water or "lose" it.

The Metropolitan Water District pays $264 an acre-foot for water. If it financed the Imperial Valley conservation work, it could expand significantly the water available to Los Angeles at costs still far below those needed for a new water development scheme.[34]

One major impediment: The irrigation district's contract with the Department of the Interior states that "water shall be delivered as ordered by the district, and reasonably required for potable and irrigation purposes within the boundaries of the district," language that is interpreted to make any transfer out of the district a contract violation.[35]

Water in the Courts

If there is wisdom in allowing water to seek its own price level, the vehicle for that wisdom may be a series of court cases that seem likely to allow greater flexibility in water management.

The most notable recent case is one that is known as the Sporhase decision (*Sporhase v. Nebraska* ex rel. Douglas, 102 S. Ct. 3456 [1982]). In Sporhase, the Supreme Court found that under the interstate commerce clause of the Constitution, the state of Nebraska could not prevent a farmer from moving well water from his property in Nebraska to irrigate crops on adjacent property in Colorado. Shortly thereafter, a suit by El Paso, Texas, forced New Mexico to lift the prohibition on water exports contained in the state constitution (*City of El Paso v. Reynolds* Civil No. 80–730–HB U.S.D.C., New Mexico [January 17, 1983]).

The degree to which water is covered by the commerce clause of the Constitution, and thus subject to the flexibility of the marketplace, is certain to remain an issue of significance in coming years. "Sporhase-authorized interstate water transfers promise to give government less, and the water market more, control over water allocation."[36]

A Colorado River Detour — To San Diego

The issue of water pricing and changes in water usage has become particularly intense in the basin of the Colorado River. This great river rises on the western slopes of the Rocky Mountains, tumbles through the Grand Canyon into the valley separating California from Arizona, then dribbles its little remaining water into Mexico.

As the Colorado descends to the sea, it collects about 15 million acre-feet of water yearly. Under a 1922 compact approved by Congress, the Colorado is divided equally between the Upper Basin (Colorado, Wyoming, Utah, New Mexico) and the Lower Basin (California, Nevada, Arizona).[37] Under the compact, as well as the laws of gravity, the Lower Basin states obtain the use of any unused water that flows out of the Upper Basin.

But a proposed for-profit water development scheme has become a source of considerable controversy within the Basin. The Galloway Group, Ltd., of Meeker, Colorado, plans to construct five dams on Colorado River tributaries in Colorado. Galloway plans to spend $6 million in 1986 to construct the initial project, a 600–acre reservoir that will yield 55,000 acre-feet of water yearly. In the spring of 1985, Galloway announced what it called the "first in a series of contracts" to sell some of that water to users in Arizona.[38]

By 1990, Galloway officials expect to have all five dams built at a cost of $200 million, dams producing an annual yield of 1.3 million acre-feet of water, with the water to be sold to a variety of downstream users, both industrial and municipal.

Galloway officials estimate that the company can build and amortize its Colorado dams, pay all power and use-of-canal costs incurred in pumping the water out of the Lower Colorado to potential customers, such as San Diego, provide "profit sharing" with Upper Basin states, and still obtain a comfortable profit.

The key potential customer appears to be the San Diego County Water Authority, which serves the city of San Diego and surrounding communities. The authority estimates its annual needs at 525,000 acre-feet of water. It holds an option from Galloway to purchase up to 500,000 acre-feet of water beginning early in the 1990s, at a price 10 percent below whatever it would otherwise have to pay its current supplier, the southern California Metropolitan Water District.

San Diego officials see the Galloway project as a way to meet interim needs until it can obtain more permanent water supplies from Northern California. Whenever a long-term California solution comes on line, the Galloway water would then revert to uses that would likely have been developed by then in the Upper Colorado Basin.

But the Galloway project is very controversial, particularly to Arizona, which now can use any "unused" Upper Basin water for "free" the same water Galloway proposes to develop and sell to the Lower Basin.

Officials of the Colorado River states argue that the Galloway plan violates the Colorado River Compact: water impounded in the Upper Basin must be used in the Upper Basin. Various state and regional groups have formally denounced Galloway's San Diego plans.[39]

Two conflicting concerns exist: With federal project funding drying up, Colorado may never be able to build all the projects it needs to retain its full water allocation; while the compact reserves water rights for each upper Basin state, California and Arizona may simply acquire "permanent" use of the water Colorado fails to develop.[40] Conversely, a water export sale by Colorado-based interests might compromise Colorado's right to reclaim the water in the future.

The Galloway-San Diego discussions have sparked interest in other innovative water transfer schemes. The Bureau of Reclamation is working on plans that might lead to the development of new water supplies in Utah, supplies to be set aside for future use by the Ute Indians, but water that might be sold temporarily to San Diego or other Lower Basin municipal users.

Market Impediments

Many impediments to a freer maket in water rights remain. As noted earlier, buyers of federal water cannot resell that water for a better price outside their water district. Moreover, as the specter of water shortages grows and new pricing patterns make it increasingly attractive to shift water into higher-priced areas, many regions have begun to erect new legal barriers against market efforts to transfer water to its higher-valued uses.

- Since 1968, the federal government has by law been prohibited from studying any potential water transfers *into* the Colorado River basin, a prohibition supported by the Columbia River states to head off any possible moves by water-poor Southern California.
- Public Law 98–434 prohibits use of federal funds to study, demonstrate, or transfer any water outside of the state of Arkansas.
- While New York City longs for new water from the Susquehanna River Basin in Pennsylvania, New York State went to court to prevent Exxon from taking water from the Hudson River to Aruba by tanker.[41]
- A group of eight states and two Canadian provinces signed a Great Lakes Charter, an agreement designed to keep Great Lakes water from being diverted out of the five Great Lakes. While no large-scale diversion plans are believed under serious consideration, the eight U.S. governors and two Canadian provincial premiers expressed a common resolve to discourage even investigation of massive diversion out of the Great Lakes. "I think it is a signal to the Sun Belt that we stand together internationally to protect our water resources," Michigan Governor James Blanchard said at the signing.[42]
- Even in basins such as the Missouri River, where only a small fraction of current river flow is utilized, strong political pressure against diversions is evident. An effort by South Dakota to sell unused Missouri River water to a coal slurry pipeline company foundered as a result of opposition from lower Missouri River Basin states, railroads, and barge companies.

Harbor Development Issues

While the opportunity for a marketplace solution could resolve many of the problems of water "need" in the West, the marketplace also offers an opportunity to develop rational solutions to other types of water problems. An excellent example involves the competition for deeper harbors along our coasts. The marketplace appears to be the key to providing early, economical deep-harbor development.

Traditionally, harbor development has been at full federal expense. And the political process has spread available federal expenditures broadly but thinly among the nation's ports. Rather than target investments, funds and work have been distributed widely among many ports; 48 ports now have authorized federal depths of 40 feet; no Atlantic or Gulf port has a depth greater than 45 feet. When one port obtains a deeper channel, many others have sought and received the same.[43]

> "While valuable in the past, this approach now thwarts the nation's ability to develop the deep harbors needed to handle the larger, more cost-effective superships. Most studies set the cost of a typical 55-foot harbor at close to half a billion dollars. It appears highly improbable that the Federal government will finance work, in any timely manner, on any of the 34 ports that have been identified by the Federal Coal Export Task Force as potential sites for major coal export harbors."[44]

But when a harbor is deepened to 55 feet, bulk vessels that are far more economical to operate — those in the 150,000-ton range — can be accommodated. Shippers in such heavily used ports as Norfolk, Virginia, might well be able to amortize these port expansion capital costs, since savings attributable to added efficiency are figured to be several times the cost.

Whenever work is paid fully by the federal government, as under current law, numerous ports can be expected to claim a "right" to share in such development. The political process, as it has in the past, will deepen many ports by small increments, rather than focusing the available and limited funds at the most productive locations.

> "In testimony before the Committee, a panel of port representatives agreed that only one to four deep-draft ports were needed initially for coal exports. However, the port representatives agreed that if the Federal Government funded the full cost of development, as occurs now, there could be as many as several dozen ports interested in expanding their capabilities to coal port status. If the Federal Government continues to fund new development, a number of 55-foot ports may exist by the early years of the 21st century. However, the necessary one to four 55-foot ports are unlikely to be developed in this decade."[45]

Conclusion

The potential exists for resolving our institutional water "crisis" when the nation understands the potential for market allocation of water resources as well as the potential for governmental failure in the allocation of that same resource. "With more reliance on markets, it is possible to have less environmental

destruction of water resources, more economic growth, and more individual freedom."[46]

User financing, which is marketplace financing, will pinpoint the location of the high-priority work. Thus, if pricing is permitted to hold a greater role in determining the use of water, the water "needs" of the United States almost certainly can be met.

In summary, as one advocate for a sounder water law argued: "Legal and institutional barriers to voluntary sale and purchase of water rights must be eliminated; public investment must only be committed to lower-cost projects; and water pricing must be reformed so consumers will face the true cost of the resources they use."[47]

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43. Senate Report 97–301, the National Harbor Improvement and Maintenance Act of 1981.
44. *Ibid.*
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Chapter 8

Energy and Minerals for National Security and Prosperity

The United States depends on many sources for its energy. Natural resources situated on the public lands and, increasingly, on the Outer Continental Shelf provide large shares of our domestic oil and gas production. In electricity generation, nuclear energy has become relatively more important, especially in certain regions. Its future significance, however, has become somewhat clouded, given recent economic problems.

The nation's quest for secure energy and mineral sources to provide for our critical and strategic needs has been troublesome. A few years ago, many felt we faced either increased dependence on vulnerable foreign supplies or severe cutbacks in energy use. However, recent developments point to a much more optimistic assessment of the energy outlook.

In the area of domestic crude oil and petroleum supplies, especially, the evidence is clear—the national energy picture in 1984 continued to be bright. Total domestic crude oil production reached its highest level since 1973 and rose for the third consecutive year. This increased supply also meant good news for consumers at the gas pump: from 1981 to 1984 the average price of a gallon of regular gas dropped 14 percent. In 1984, the nation relied significantly less on imports of these products than was the case several years ago. Since 1982, net stock-adjusted imports of oil on average have remained at about 26 percent of the total domestic product supplied.

This progress was largely due to President Reagan's decontrol of domestic petroleum markets and removal of restrictions on energy use. This decontrol experience suggests that moving toward a free market in natural gas would also advance the nation's energy situation.

Potential new sources of energy are also possible from exploration in the "new frontier" of the U.S.—the Exclusive Economic Zone (EEZ). 1984 marked the first anniversary of the creation of the EEZ—an area larger than the country's land mass and expected to contain vast hard-mineral and oil and gas deposits. Our perception of the EEZ is changing as we realize its potential as a source of elements and exotic life forms, many of which are likely to have scientific, medical, and commercial importance. Although exploration of much of the EEZ and recovery of these resources is hampered by difficult engineering-mining problems, recent technological advances are making even deep waters more accessible.

The Outer Continental Shelf (OCS) portion of the EEZ already provides significant amounts of the nation's energy and mineral needs. In 1984, 12 percent of total domestic oil production and 25 percent of domestic natural gas production came from offshore, and some predict that these areas will provide over half of our future domestic petroleum production. Exploratory and development activities in the OCS are monitored closely for their effects on marine life and for their contributions to ocean oil pollution. These programs, which

attempt to ensure that all OCS resources are protected, appear to have been very successful to date. With recent findings in the EEZ of important and unusual lifeforms and formations, research to learn more about the deep water habitat has accelerated.

In the nation's public lands also, the principles of balanced multiple-use management apply. Under the auspices of the Bureau of Land Management (BLM), approximately 600 million acres of the federal mineral estate are administered. Of this amount, 130 million acres are under lease for oil and gas exploration and over 944,000 acres are leased for coal production.

Nuclear power, a once highly promising source of energy, has encountered economic problems. Nonetheless, last year, nuclear power became the second leading source of electricity generation in the U.S. In 1984, over 13 percent of the nation's electricity was generated by nuclear plants. A critical issue in nuclear power generation continues to be how best to address the need for radioactive wastes to be safely isolated for long periods of time. Currently, high-level wastes are stored temporarily at nearly 100 sites around the country. The 1982 legislation dealing with the management of such wastes defines a complex path to arrive at a way of ultimately storing nuclear wastes in geologic respositories, the costs to be paid by owners and generators of high-level wastes and spent fuels with a nuclear waste fund to be established and financed via user fees on ratepayers who use nuclear-generated electricity.

Three sites have been proposed for ultimate disposal of nuclear wastes. In assessing the viability of these sites, the government agency responsible, the Department of Energy, is seeking to address areas of concern to the affected parties and to involve the public in discussions of the public health and safety issues involved.

The following sections discuss in more detail the current status of the U.S. domestic energy situation, and the principal sources of those energy and mineral revenues that will be available to fulfill the growing economic requirements of the nation.

The Really Good News About Energy

In 1979, the Council on Environmental Quality's tenth annual report offered a gloomy assessment of America's energy outlook:

> "The U.S. energy dilemma was painfully apparent in the summer of 1979. The long lines and short tempers at gasoline stations were clear evidence of the nation's continuing vulnerability to interruptions of oil supply through events beyond its control . . .
>
> "The nation's century-long predominance as the world's greatest producer of oil is over. U.S. oil production peaked in 1970, but our appetite for oil has continued to grow."[1]

While pessimistic, the 1979 Council's projections were fully consistent with the views of many energy "experts" of the time. In the 1979–1980 era, almost no experts—government academics, or even industry—would have forecast that in less than five years Americans' relative ability to buy gasoline would increase

by 50 percent, that United States oil production would hit a 10-year high, or that energy consumption per unit of economic output would decrease 13 percent. Had they done so, they would have been ridiculed as dreamers. Yet, in every case, the "experts" were wrong; in each case the event came to pass.

What Really Happened

Crude Oil Prices

In the first few weeks of his first term, President Reagan ordered the immediate decontrol of domestic petroleum and the removal, where possible, of restrictions on energy use. Energy experts and others supportive of the status quo sounded the alarm. One congressman, now chairman of an important energy subcommittee, warned that oil decontrol "as a cure will prove worse than the disease" and described Saudi oil minister Yamani's prediction at that time of imminent $50-a-barrel oil as "optimistic."[2] In 1981 a Conoco vice president said that oil prices "are not likely to weaken from present levels"; a Sohio executive observed, "An important point is that nobody is predicting a downturn in oil prices."[3]

What happened? Oil prices peaked in March 1981, two months after decontrol had brought the full market price incentive to bear on all producers and consumers, and then began a long, nearly continuous decline. From 1981 to 1984 the average annual refiner acquisition cost of imported crude oil fell from $37.05 per barrel to $28.88 per barrel—a drop of more than 22 percent. In December 1984 the average refiner acquisition cost of imported crude oil was $28.02 per barrel, about $11.00 per barrel less than the peak monthly price of $39.00 per barrel reached in February 1981. Adjusted for inflation, the cost of imported oil to U.S. refiners declined 42 percent from February 1981 to December 1984 (Figure 8–1).

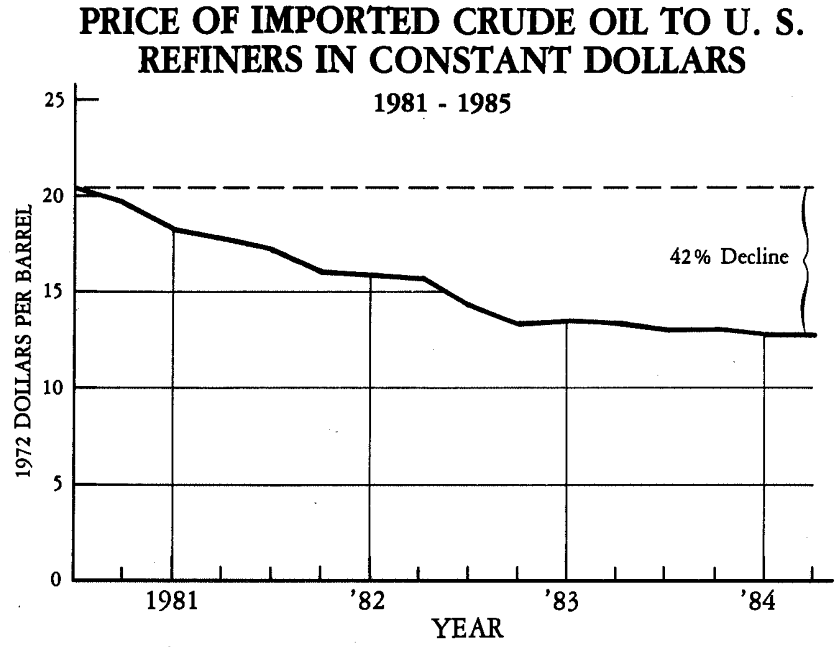
Gasoline Prices

In January 1981 a Sunoco spokesman said that "undoubtedly there will be more increases" in gasoline prices "now that we've had decontrol."[4] In fact, the benefits of lower crude oil prices were largely passed on to American consumers. From 1981 to 1984 the average price of a gallon of regular gasoline dropped 14 percent; adjusted for inflation, gasoline prices declined 25 percent. In 1984 a gallon of leaded regular gasoline cost about the same in constant dollars as it did in 1956. Moreover, as shown in Figure 8–2, the amount of leaded regular gasoline purchasable with one percent of per capita income increased 50 percent from 1981 to 1984.

Oil Imports

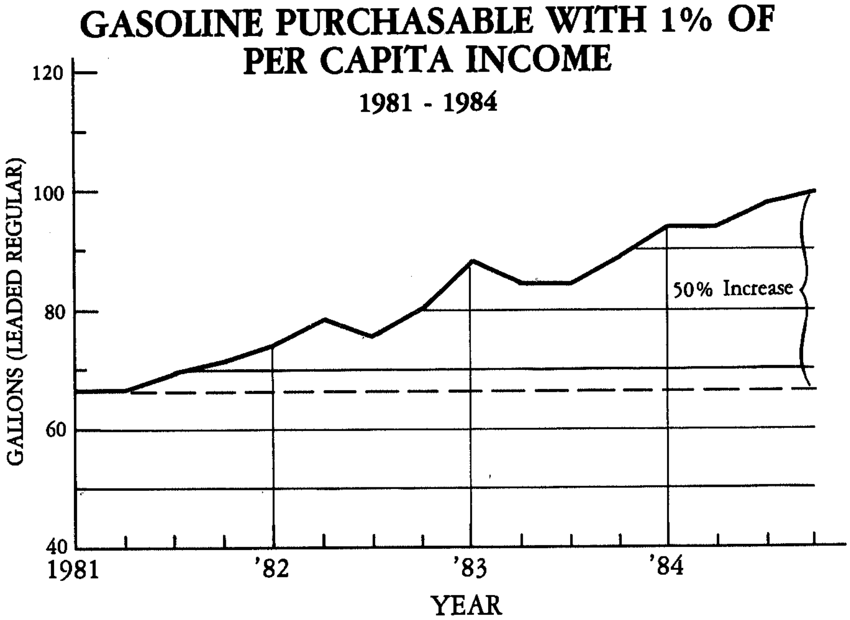
"Although estimates vary," the first National Energy Plan warned in 1977, "the most reasonable range of estimates of 1985 world oil imports is 12 to 16 million barrels per day."[5] The Congressional Budget Office (CBO) projected in 1980 that U.S. oil imports would rise to 10.1 million barrels per day by 1985, or about 52 percent of total product supplied.[6]

FIGURE 8-1



SOURCE: Energy Information Administration.

FIGURE 8-2



SOURCE: Energy Information Administration.

The most expansive measure of U.S. imports is on a *gross* basis. In 1984 gross imports of crude oil and petroleum products averaged 5.38 million barrels per day, about one-third to one-half the level projected in the 1977 Plan. In fact, this import level is about 14 percent below the 1973 level of 6.26 million barrels per day and about 40 percent below the 1977 peak of 8.81 million barrels per day. In March, May, and July 1977, and in September 1978, gross imports exceeded 50 percent of domestic petroleum product supplied. However, on a 12-month rolling average basis, gross imports as a percentage of domestic product supplied had peaked at 47.8 percent by December 1977; by February 1983, this import ratio had fallen to 32.8 percent. In 1984 gross imports of crude oil and petroleum products rose slightly to 34.3 percent of total domestic product supplied.

In discussing U.S. import dependence, a more reasonable measure, however, is net imports, stock-adjusted, but omitting all imports going into the Strategic Petroleum Reserve. On that basis, there is no indication that imports are rising significantly as a percentage of total domestic consumption or in absolute terms. Net stock-adjusted imports fell from 8.10 million barrels per day in 1977 to 4.38 million barrels per day in 1984—a decline of more than 45 percent. Net stock-adjusted imports averaged between 4.3 and 4.5 million barrels per day in each of the past three years. As shown in Figure 8–3, for the 12 months ending December 1984, average net stock-adjusted imports were 27.9 percent of total domestic product supplied—well below the 43.9 percent peak reached in August-September 1977 and significantly below the 32.4 percent level for the 12 months ending December 1973. On a 12-month rolling average basis, net stock-adjusted imports have remained at about 28 percent of total domestic product supplied since December 1982.

Domestic Oil Production

In 1979 and 1980 a number of government institutions—including the Energy Information Administration, Congressional Budget Office, General Accounting Office, and Office of Technology Assessment—projected that 1985 domestic crude oil (and natural gas liquids) production would be significantly below the 1979 level of 10.2 million barrels per day (Figure 8–4). Their estimates for 1985 ranged from a low of 7.2 million barrels per day to a high of 9.4 million barrels per day.[7]

In fact, domestic crude oil production in 1984 had *increased* about 280,000 barrels per day over 1979 and averaged 10.5 million barrels per day. The 1979–1980 government projections had ***underestimated*** 1984 production by from one million to three million barrels per day. Again, the experts were wrong—dramatically so.

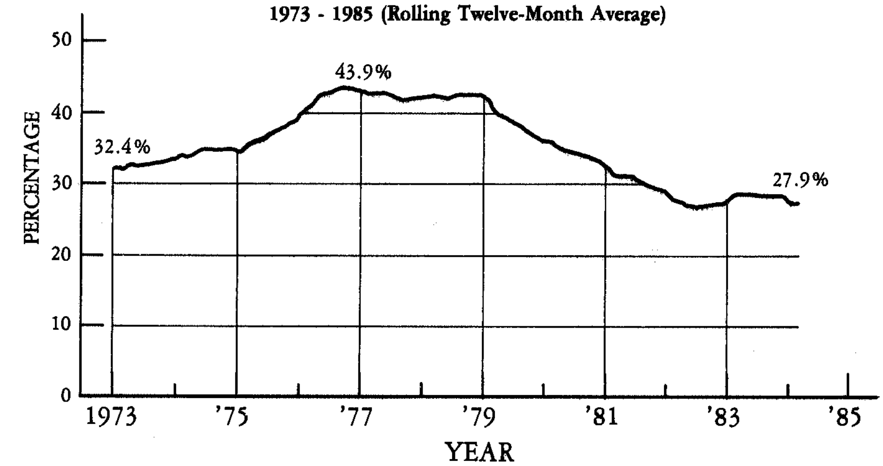
Total domestic crude oil production rose in 1984 for the third consecutive year, reaching the highest level for any year since 1973. The combined total of crude oil and natural gas liquids (NGL) production in 1984 was also the highest since 1973 and has increased every year since 1979. The 1984 production level of 10.5 million barrels per day for crude and NGLs was exceeded in 1973 by less than 450,000 barrels per day.

This level of production has required prodigious exploration and development. Between about 75,000 and 90,000 wells were completed each year from

FIGURE 8-3

U. S. NET IMPORTS OF CRUDE OIL AND PETROLEUM PRODUCTS (STOCK-ADJUSTED, LESS SPR IMPORTS) AS A PERCENTAGE OF TOTAL DOMESTIC PETROLEUM PRODUCTS SUPPLIED

1973 - 1985 (Rolling Twelve-Month Average)

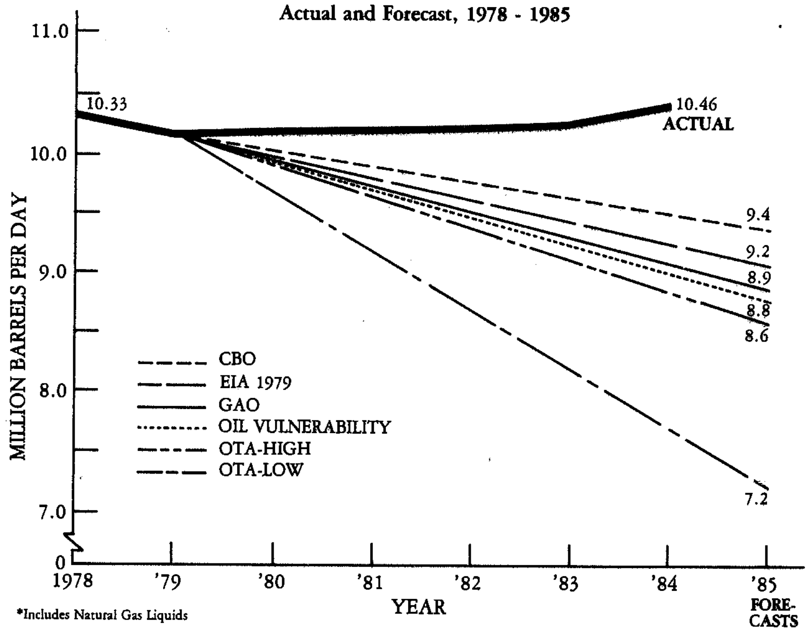


SOURCE: Data used in preparing the Monthly Energy Review Issue dated January 1985 (published in April 1985), obtained from the Monthly Energy Data System (MEDS). Energy Information Administration.

FIGURE 8-4

DOMESTIC OIL* PRODUCTION

Actual and Forecast, 1978 - 1985



*Includes Natural Gas Liquids

SOURCE: U.S. Department of Energy.

1981 to 1984—a level substantially higher than the 1975–1980 average of about 45,000 wells per year. While the number of rigs operating declined about 39 percent from 1981 to 1984, the number of wells drilled per rig increased 48 percent in the same period.

Clearly, the assumptions in the 1979 CEQ *Environmental Quality Report* about the direction U.S. energy markets would take have been proven wrong by the events of the past four years. Where the 1979 Council saw only crisis, the 1984 Council finds substantial reason for optimism in America's energy outlook.

The Roots of Progress

America has achieved this substantial turnaround largely through a change in energy policy. Throughout most of the 1970s, successive Administrations and Congresses undertook policies and programs that attempted to manage both supply and demand. Federal rules would direct the type of energy Americans would produce and the ways in which they would be permitted to consume it. This philosophy was clearly evident in publications by the Council on Environmental Quality in 1979.

For example, a CEQ report, *The Good News About Energy*, published in February 1979, examined "the possible contribution that increased energy productivity could make in meeting national energy, economic, and environmental goals." Here, the 1979 Council sounded optimistic: "The United States can do well, indeed prosper, on much less energy than has been commonly supposed." To achieve these energy efficiency gains, the 1979 Council did not intend to rely on consumer choice or competition, however. According to the Council:

> ". . . [T]he full potential for greater energy productivity is not likely to be realized without some important institutional changes. These could take the form of regulatory requirements or economic inducements."[8]

Four years ago, the incoming Reagan Administration immediately moved to reject such centralized energy policies. To ensure Americans adequate energy at reasonable cost, the Reagan Administration elected to emphasize individual choice and market forces. This energy strategy reflects some painful lessons America has learned over the past several decades and reflects a renewed appreciation of the role of the market in producing national growth and prosperity. The resulting approach has been, first, to minimize federal control and involvement in energy markets while maintaining public health and safety and environmental quality; and, second, to promote a balanced and mixed energy resource system. This two-fold approach offers the best assurance that individuals and businesses throughout the nation will have abundant and affordable energy available when, where, and in the form needed.

Confidence, But Not Complacency

This review provides every reason to be optimistic, but provides no excuse to be foolish. If America does not develop scientific and technological improvements at a sufficiently rapid pace to allow increased energy production

or improved energy utilization at reasonable costs, then energy imports may rise excessively, making us increasingly vulnerable to foreign supply disruptions. If government actions obstruct energy production and retard sensible energy uses, we can expect similar adverse consequences. Thus, while the Council recognizes the substantial energy progress achieved to date, it notes the need for a number of additional policy reforms.

In 1984, 41 percent of total United States energy consumption came from petroleum. Net imports provided about 27 percent of total domestic oil products consumed in 1984.

The Energy Information Administration's *Annual Energy Outlook* for 1984 contains a range of projections for U.S. oil imports through 1995. The range of net oil imports implied for 1995 by the basic scenario in the *Outlook* is 5.2 to 11.7 million barrels per day, or between 31 percent and 61 percent of total consumption. Even for those projections, however, U.S. domestic crude oil production will have to total 7.6 to 11.2 million barrels per day. Between 55 and 70 percent of domestic crude oil production in 1995 will have to come from reserves not yet identified.

All such forecasts are highly speculative and should never be the sole basis upon which to determine national energy policy. However, it is clear that the nation's energy security depends upon continued replenishment of resources. New discoveries, however, require that drilling be carried out expeditiously.

In addition, it is important to recognize that substantial benefits of increased competition and lower prices—benefits, for example, that resulted from the full decontrol of domestic crude oil in 1981—would similarly result were natural gas to be fully decontrolled. The January 1, 1985, partial decontrol under the Natural Gas Policy Act is already effecting some of these changes.

From 1983 to 1984 total U.S. consumption of natural gas rose from about 16.8 trillion cubic feet to about 17.5 trillion cubic feet. Most of this growth in consumption resulted from increased economic activity, offsetting slightly warmer weather from 1983 to 1984. Increased demand also reflects the consumer's response to lower gas prices that have resulted from contract negotiations and spot market sales. The Energy Information Administration projects that total consumption for 1985 will further increase to about 18 trillion cubic feet of natural gas.

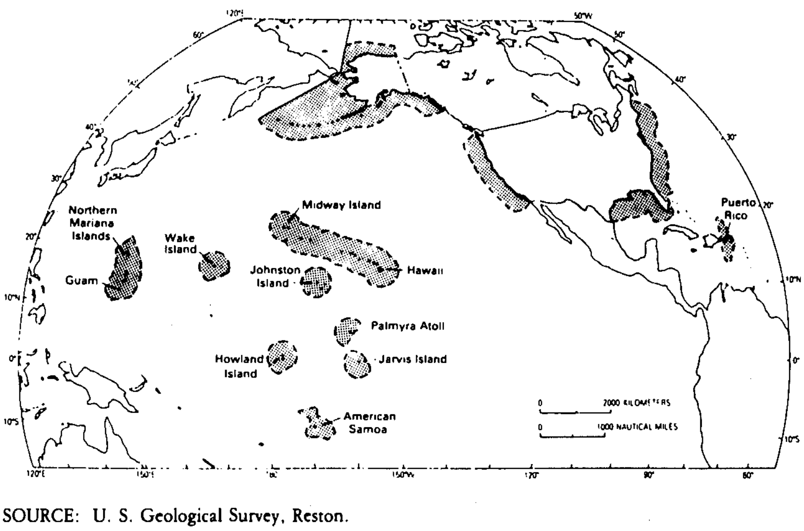
Downward pressure on natural gas prices, despite increased demand for gas due to the expanding U.S. economy, has to a large degree resulted from increased competition. America's energy progress could be accelerated almost immediately by moving toward a free market in natural gas.

The Exclusive Economic Zone: America's New Frontier

March 10, 1984 was the first anniversary of President Reagan's Exclusive Economic Zone (EEZ) Proclamation. The Proclamation established "sovereign rights" and control over resources and jurisdiction in an area that encompasses some 3.9 billion acres (see Figure 8–5), significantly more than the 2.3 billion land acres of this nation and its territories.[9] (Figure 8–6 presents the different terms used to describe offshore boundaries.) The Proclamation has been seen as one of the most important scientific and technical challenges taken on by

FIGURE 8-5

EXCLUSIVE ECONOMIC ZONE (EEZ) OF THE UNITED STATES, COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS, AND THE UNITED STATES OVERSEAS TERRITORIES AND POSSESSIONS
(Outlines of Map are Approximate)



SOURCE: U. S. Geological Survey, Reston.

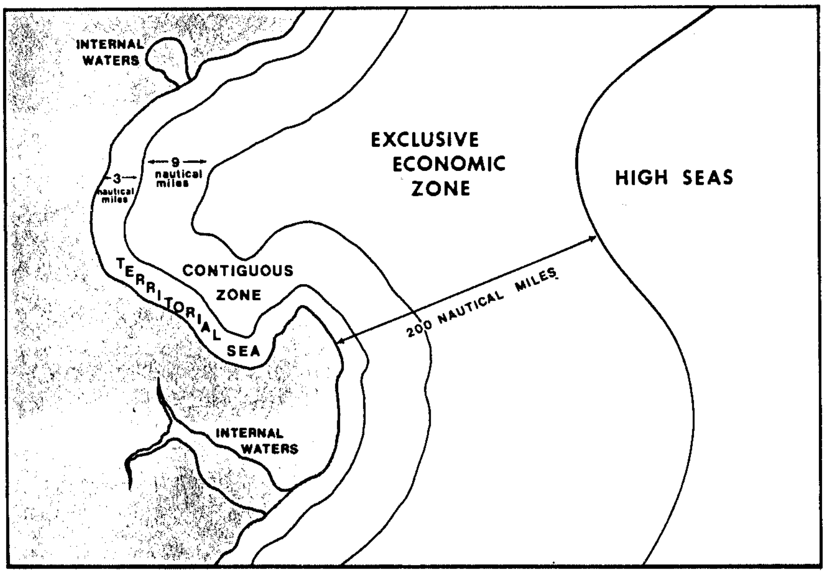
a president in the twentieth century. Some have suggested that the EEZ Proclamation may one day rank in significance with Thomas Jefferson's Louisiana Purchase,[10] James Knox Polk's expansion of the West, or Secretary of State Seward's white elephant (called Alaska) purchased from Russia during the presidency of Abraham Lincoln. Whether this proves to be true depends on how effectively the public and private sectors cooperate to explore and develop this vast watery region of which less than 3 percent has ever been explored.

Many of the resources available in the EEZ have been described as either critical or strategic to this nation. In 1984 every man, woman, and child in the U.S. required 40,000 pounds of new minerals. In a lifetime, each American will "use" a half ton each of lead and zinc, two tons of aluminum, and 45 tons of iron and steel.[11] In 1984 the Congressional Office of Technology Assessment (OTA) reported that three nations—South Africa, Zaire, and the U.S.S.R.—account for over 70 percent of the world's production of chromium, cobalt, manganese, and platinum group metals.[12] None of these metals is currently mined in the U.S. The U.S. depends upon foreign sources to meet over half of its consumption of nearly two dozen "hard rock" or "metallic" minerals, such as the following:

- Cobalt (hardener of steel and super alloy for cutting tools and jet engine parts): 93 percent (from Zaire, Zambia, and Finland).
- Manganese (fundamental alloy for virtually all steels and most cast iron): 97 percent (from Gabon, Brazil, and South Africa).

FIGURE 8-6

INTERNATIONAL LAW RECOGNIZES FIVE DIFFERENT WATER AREAS IN RELATION TO THE COUNTRY'S SHORELINE - INTERNATIONAL WATERS, THE TERRITORIAL SEA, THE CONTIGUOUS ZONE, THE EXCLUSIVE ECONOMIC ZONE AND THE HIGH SEAS



SOURCE: *Oceanus,* Woods Hole Oceanographic Institution.

- Nickel: (alloyed for corrosion resistance, widespread in aircraft and shipbuilding): 75 percent (from Canada, Norway, New Caledonia, and the Dominican Republic).

Because these metals are essential in the production of high temperature alloys, steel and stainless steel, industrial and automotive catalysts, electronics, and other applications, they are critical to the U.S. economy and national defense.

Recently, high concentrations of cobalt have been found in ferromanganese nodules, crusts, and slabs on the sides of several seamounts in the U.S. EEZ of the Central Pacific. It has been estimated that a single seamount (there are over 200 in the EEZ of the Hawaiian Islands) could yield up to four million tons of ore, making these deposits far larger than any known source on land. Yet our firm scientific knowledge about the subsea geologic provinces of this deep water frontier and their seafloor mineral resource potential is rudimentary.

Hard-Mineral Resources

Three key hard-mineral resource types are available in the United States

EEZ[13,14]: (1) manganese nodules, (2) cobalt-ferromanganese crusts, and (3) polymetallic sulfides.

Manganese Nodules

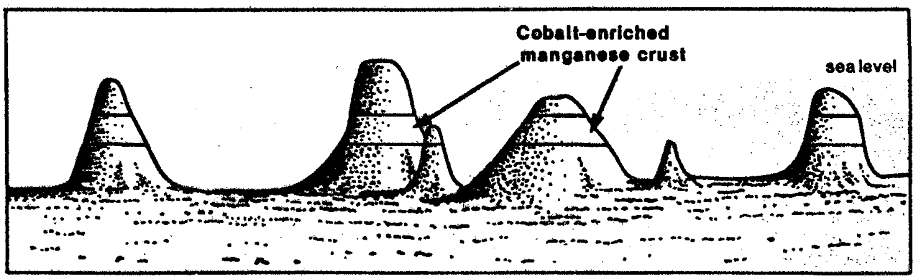
Manganese nodules, rich in nickel, copper, and cobalt have been found within the United States EEZ on both the east (Blake Plateau) and west coasts, Hawaii, and the Pacific Island territories. However, within the EEZ, they do not appear to be as abundant as in the Central Pacific, and their distribution, quality or quantity, is not known. Manganese nodules from the United States EEZ were first collected in 1885 on the Blake Plateau of the Georgia and South Carolina Coasts. In July, 1970 Deepsea Ventures completed the first ocean mining tests and environmental effects studies at sea on the Blake Plateau. In these tests, platinum was found in the modules at concentrations of 0.1 to 0.5 grams/ton. The areas with the highest potential for development will be within the EEZ of Hawaii and within the Pacific Island territories. In the Kauai (in the Hawaiian Islands) Channel off the Island of Kauai, ferromanganese deposits were found in water depths of 1200 to 2400 meters almost the entire length of the eight mile long channel.

Cobalt-Ferromanganese Crusts

The newly formed ferromanganese nodules, crusts, and slabs on the sides of several seamounts in the EEZ of the Central Pacific are rich in cobalt. Mining these crusts, located on irregular steep-sided seamounts (submarine volcanoes) pose difficult engineering-mining problems. (See Figure 8–7.) These cobalt rich manganese oxide crusts (which have been found as a coating on phosphorite or on hard substrates on the flanks of islands or tops of seamounts at water depths of 1000 to 2500 meters) have an average concentration of about

FIGURE 8-7

COBALT-RICH MANGANESE CRUSTS OCCUR ON THE FLANKS OF VOLCANIC ISLANDS AND SEAMOUNTS



SOURCE: U. S. Geological Survey, Reston.

1 percent cobalt. Crust thickness of more than 2 cm may yield accessible concentrations of about 16 kg of ore per square meter of crustal surface. Approximately 100 of these seamounts exist in the EEZ of the Hawaiian Islands and Line Islands alone.

Polymetallic Sulfides

Polymetallic sulfides have been recovered from the sea floor as oxidized massive sulfide and fresh sulfides from several parts of the eastern Pacific Ocean. These sulfides, high in copper, zinc, and silver, are found in many onshore areas, in such places as Canada, Cyprus, India, Italy, the Philippines, the Soviet Union, and Turkey. The discovery in 1979 of hydrothermal vents on the East Pacific Rise at the mouth of the Gulf of California supported the hypothesis that polymetallic sulfide deposits were formed as a result of sea-floor volcanism. Studies using the Deepsea submersible *Alvin* (Woods Hole Oceanographic Institution) found active hydrothermal vents with fluid temperatures exceeding 350 degrees centigrade. The geysers are commonly called "black smokers" because the plumes contain enough sulfide to be black in color (see Figure 8–8). The sulfide mineralization is hydrothermally produced when deeply circulating very hot sea water leaches heavy metals and sulfur from rocks below the sea floor that are precipitated from solution as iron, copper, zinc, and silver sulfides, and anhydrite (calcium sulfate) as they vent from "black smokers" (of the thermal springs) by mixing with cold (2 degrees centigrade) sea water along the axial zones of spreading centers. In 1981 similar deposits were discovered at the Galapagos Rift, the Guaymas basin within the Gulf of California, the Juan de Fuca Ridge (which extends into the EEZ of Canada). (See Figure 8–9).

Recent Exploratory Activities

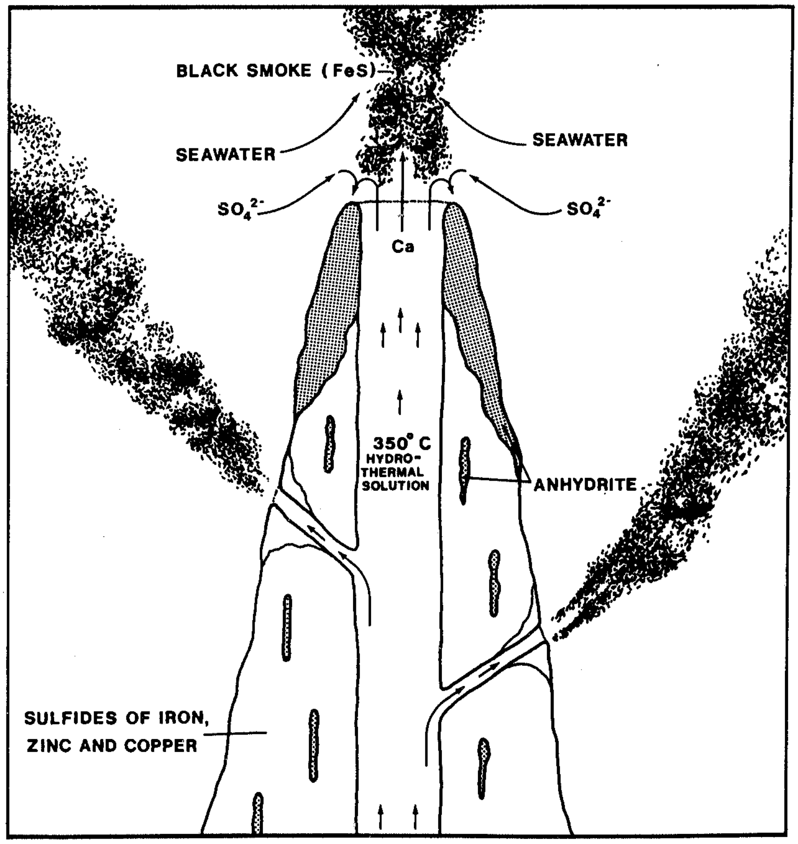
With regard to sea floor surveys, two federal agencies, National Oceanic and Atmospheric Administration (NOAA) and the the U.S. Geological Survey (USGS), signed a Memorandum of Understanding in April 1984 for cooperation and coordination. In May 1984, the NOAA Ship *Surveyor* began a Seabeam swath bathymetry survey off the northern coast of California. At the same time the USGS began a *Gloria* long-range sidescan survey of the EEZ off southern California. Since the Department of the Interior Symposium in 1983,[15] two cruises have been undertaken to map the distribution and resource potential of cobalt-ferromanganese crusts in the Pacific. In summer of 1985 both NOAA and the USGS will be conducting surveys of the polymetallic sulfide deposits off the states of Washington and Oregon. With the completion of the USGS West Coast activity, the next project will involve sonar scanning of the deep water Gulf Coast region.

Recent Leasing Activities

The Office of Strategic and International Minerals (OSIM) of the Minerals Management Service (MMS) of the Department of the Interior is responsible for the development and oversight of a leasing and regulatory program for

FIGURE 8-8

BLACK SMOKERS FORM BY THE PRECIPITATION OF ANHYDRITE ($CaSO_4$) AND IRON-ZINC-COPPER SULFIDES



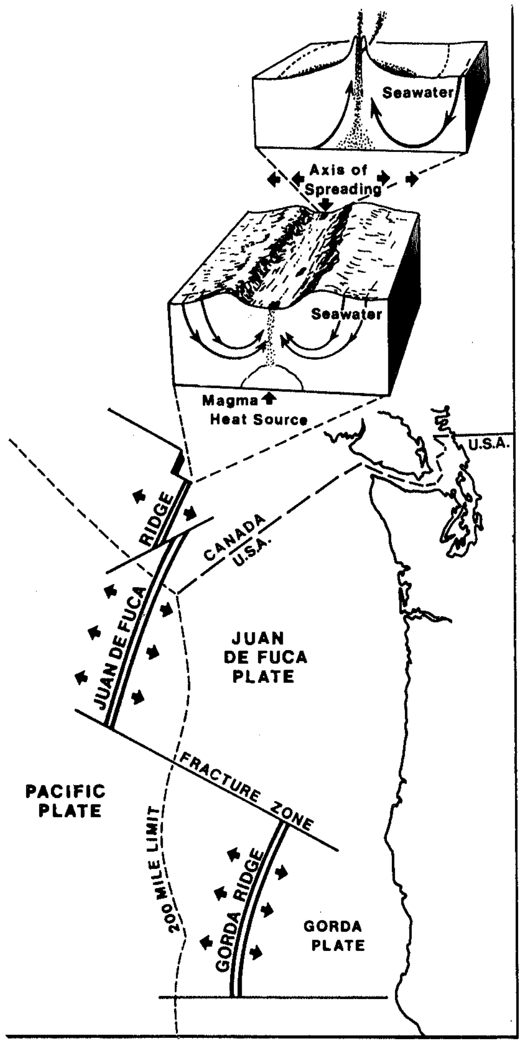
SOURCE: *Oceanus*, Woods Hole Oceanographic Institution.

nonenergy minerals in the United States Outer Continental Shelf/Exclusive Economic Zone (OCS/EEZ). The authority for leasing comes from the Outer Continental Shelf Lands Act (OCSLA), amended in 1978.

Gorda Ridge

Shortly after the EEZ was declared, MMS began preparation of an Environmental Impact Statement (EIS) for leasing polymetallic sulfides on the Gorda Ridge offshore Oregon and California. The OSIM was formed as the Gorda Ridge draft EIS neared completion and supervised its completion.

FIGURE 8-9



Polymetallic sulfides are formed at mid-ocean ridges, where seawater heated by magma leaches minerals from the seafloor. Such sulfide deposits have been found on the Juan de Fuca ridge within the EEZ of Canada, but have not yet been encountered on the Gorda Ridge.

SOURCE: *Oceanus*, Woods Hole Oceanographic Institution, Winter 1984/1985.

Following the hearings on the draft EIS, Secretary Clark and Governor Atiyeh of Oregon formed a joint Federal/State Task Force in February 1984 to review the responses to the draft and direct any studies needed to fill significant data gaps. (California joined the Gorda Ridge Task Force in June 1984.) During the same period, DOI began work on a cobalt-rich manganese crust leasing proposal within the Hawaiian EEZ in cooperation with Governor Ariyoshi of Hawaii.

The Gorda Ridge Task Force will forward a recommendation to the Secretary of the Interior late in 1985 or early 1986 regarding the continuation of the Gorda Ridge leasing proposal. At this time the presence of an economic resource in the area is questionable. However, limited, active venting has been recently reported by NOAA from the geologically similar Mid-Atlantic Ridge.

Hawaii

MMS initiated the Hawaii EEZ crust project in February 1984 with the formation of the Joint Federal/State Technical Task Force by Secretary Clark and Governor Ariyoshi. The Task Force is overseeing the preparation of the lease sale EIS.

The study area includes the Hawaiian EEZ, extending 200 nautical miles in each direction from the Hawaiian archipelago from the Island of Hawaii northwesterly 1200 miles past Midway Island to Kure Island, and the Johnston Island EEZ. Johnston Island is located 800 miles southwest of Oahu. Not included within this study area are the major populated Hawaiian Islands and the Hawaiian National Wildlife Refuge, as proposed. The study area currently consists of 400 million acres of submerged lands.

Cobalt-rich manganese crusts exist as thin coatings on the surficial rock. They are especially thick (2–5 inches) and high in strategic metal content on ancient seamounts in water depths of 800 to 2600 meters (2600 to 8600 feet). The resources being studied at these water depths are below major fisheries and other biological resources, and the environmental impacts from mining are considered minimal. The significant mining consequences include the possibility of waste disposal at sea causing a sediment plume and sea bottom turbidity from mining these surficial crusts. The significant processing-plant consequences include energy and water requirements, compatible land use, and waste disposal and emission considerations.

Public information and EIS scoping meetings were originally held in Honolulu on April 30, 1984, and in Hilo on May 1, 1984. Repetition of scoping meetings based on the recent Johnston Island EEZ inclusion occurred at Kauai, Maui, Honolulu, and Hilo on May 6–9, 1985.

The Minerals Management Service has obligated $0.5 million in fiscal year 1985 for the completion of the EIS by the State. Additional environmental baseline studies, including site-specific studies, will be completed from this funding. The draft EIS is scheduled to be completed in March 1986. This completion date was recently extended to allow for the inclusion of the Johnston Island EEZ into the project study area. With the Secretary's approval, the lease sale will be conducted in April 1987.

Oil and Gas Resources

The production value of subsea oil and gas currently recovered from the U.S.

EEZ is approximately $22 billion annually (additional funds accrue to the U.S. Treasury in the form of bonuses, royalties, and taxes, which are about $7 billion annually). In comparison to other current EEZ resources, fisheries landings were about $4.5 billion, and about $2.8 million is received from federal salt and sulfur leases and hard minerals. In terms of strategic importance in 1984, oil production offshore accounted for about 12 percent of the total U.S. production, while offshore gas production accounted for about 25 percent of the total U.S. production. Currently, 90 percent of the oil and almost 100 percent of the natural gas produced in federal waters comes from the Gulf of Mexico, with the remainder from off California. No oil is currently being produced from federal lands offshore of Alaska; however, Shell Oil Company has discovered oil at Seal Island and has estimated that the field is about 300 million barrels. It is generally believed that a significant portion of the undiscovered hydrocarbon resource potential of this nation is contained in the Outer Continental Shelf (OCS). In the 1970s great expectations arose from both federal and industry estimates of undiscovered oil and gas resources on the Atlantic OCS. Since then, the oil industry has drilled 43 wells in several of the identified major areas on the eastern U.S. coast without a commercial discovery. Additional drilling in the Alaskan OCS areas thought most promising has also been disappointing. The trend in frontier exploration is toward drilling in deeper water depths, with Shell setting several deep-water drilling records. Associated with increased emphasis on deep-water exploration is a companion emphasis on development of appropriate deep-water production technology.

Future Ocean Uses in the EEZ

Energy

A major renewable source of ocean energy that has been initially studied in the past two years has been the use of thermal gradients, such as proposed in the ocean thermal energy conversion (OTEC) electric power plants. The concept (first proposed in 1881) uses warm solar-heated surface waters to cause a working fluid (e.g., ammonia) to evaporate, with the expanding vapor rotating a turbine attached to an electric generator. Then very cold (near freezing) ocean water is pumped to the surface to cool and reliquify the ammonia vapor. Because ocean surface waters store heat very effectively, ocean thermal energy is available day or night (unlike solar energy collectors photocells).

In 1984, NOAA's Special Projects Office coordinated ocean engineering research for the Department of Energy's Ocean Thermal Energy Conversion (OTEC) Program. NOAA is conducting research on the high technical risk areas to develop a technical information base intended for use by industry to develop future commercially viable systems. These efforts have resulted in conceptual and preliminary baseline designs for floating (moored and grazing) and fixed (land-based and shelf-mounted) systems, developments of hydrodynamic and structural design models, small-scale laboratory experiments, larger scale at-sea tests, and development of procedures for inspection, maintenance, and repair. Several small-scale prototype plants are being tested. In April 1983 at-sea testing began on a one third-third scale (of a 40 megawatt plant), with Phase II for conducting tests of the cold water pipe (CWP) suspended from

a moored barge off Honolulu Harbor, and Phase III for deployment and installation (April 1984) of the same pipe on foundations prepared on the 40-degree slope off Keahole Point on the west coast of the island of Hawaii. These tests are being conducted to measure forces due primarily to currents and waves. The long-term survivability of steep slope OTEC installations is considered to be the major technical risk associated with their development. The 40 MW shelf-based plant proposed for Kahe Point, Oahu, Hawaii, will require a CWP of over 900 m down a steep slope. The Keahole Point plant will be a 12–month experiment to test the design structure for a 10-year storm wave height of 7.5 m and peak currents of 1.6 m/s during this past winter.

As a new energy source for the 1980s, OTEC has been slow to develop because the original emphasis was placed on large-capacity (over 100 MW) plants that would compete economically with oil-fired or nuclear plants. In the late 1970s the progressive increases in the cost of fuel oil focused development toward these large-capacity plants, with high capital risks. However, the softening of oil prices in the 1980s slowed down development and testing. To date, only small (100 KW) OTEC pilot plants have been built and operated for short periods of time.[16] The Administration has determined that continued development of OTEC technology will be conducted by the private sector.

Biotechnology/Industrial Products from the Sea

New industrial products are being developed from marine organisms from the EEZ by researchers in private industry and academic institutions.[17] Wax esters have been collected from mid-water and deep-water fishes. Tissues of these deep-water fishes have been found to hold up to 4.5 percent of an oil that contained 90 percent wax esters. Until 1970 these esters, which are used in high-pressure lubricants, came from the blubber of sperm whales. Cod fish liver oil has been known for years to be an excellent source of vitamins A and D. A green algae, *Dunaliella*, when grown in a high salt environment has been found to produce glycerol and store it in quantitites up to 80 percent of its dry weight. This glycerol could be used in cosmetics, plastics, and explosives. Seafood processing wastes have been found to contain up to 30 percent chitin which can be extruded to form surgical sutures to promote wound healing and are biodegradable. Biopolymers (such as chitosan, from seafood wastes) may be used in the extraction of valuable elements from sea water (such as uranium) because of their high complexing powers.

In 1984 a wide range of products were extracted from marine organisms collected or cultured in the U.S. EEZ and marketed by U.S. companies on a global basis. Agar and alginic acids (from seaweeds) have been marketed for use by microbiologists in laboratory media. Carrageen, a protein from the red seaweeds, is widely used as an extender in foods and related products (powdered milk to toothpaste). Giant kelp (a brown seaweed) has been used for years as a food supplement; it is high in iodine, potassium, vitamins, and carbohydrates. Farmers in Europe have used kelp as a fertilizer and a source of potash. Kelp is also the principal source of algin, a natural compound contained in the cell walls of kelp, which is used by many industries as a thickening, stabilizing, suspending, and gelling agent (for example, in milkshakes, dairy products, cake mixes, beer, etc.). Algin has the unique characteristic of being able to control

the properties of mixtures containing water, stabilizing for smooth texture and uniform thawing. The kelp industry in California has harvested as much as 156,000 metric tons per year of kelp.

The isolation and commercial production of *Limulus* ameobocyte lysate (LAL) from the horsehoe crab has developed into the most significant pharmaceutical product from the EEZ; LAL can detect minute amounts of bacterial toxins. LAL is important because, although the water used in manufacturing pharmaceuticals is treated and sterilized, bacteria endotoxins can remain in solution and contaminate the drugs. To check this possibility, minute quantities of LAL are added to liquid pharmaceutical products, since LAL forms a gel or clot in the solution when an endotoxin is present.

The recent advances in genetic engineering will allow for the excision of genetic material from a "producer" organism, which is then inserted in a receptor bacteria, so that the "engineered" bacteria can produce in mass culture the desired compound(s) of the "producer" organism. Through the use of such new techniques, production of exotic chemicals found in marine plants and animals is now within reach of industrial production.[18]

Research, Technology, and Information Management

Three significant scientific advances have occurred in the past decade that affect resource development philosophies about the potential resources of the EEZ:[19] (1) the presence and uniqueness of deep-sea organisms in population levels greater than previously considered; (2) the discovery of exotic biological, geophysical, and geochemical processes at seafloor spreading centers; and (3) the potential development of biotechnology and pharmacology products from the sea. Until these discoveries, the deep ocean had been considered a biological desert and the ultimate sink for materials from land. The finding of hydrothermal springs and cold seeps discharging materials from ridges and exotic life forms has completely reversed our thinking about the deep sea. Our perception of the ocean basin has changed from that of a passive sink to that of an active source of elements. Where once we saw little value, we now see considerable potential for mineral deposits. Rather than biologically barren deserts, we now view oases rich in new life forms, with a food chain based on chemosynthesis rather than photosynthesis. Considering that some 65,000 km of ocean spreading centers occur, the potential impact of these marine hydrothermal (venting) processes upon the marine physical and biological sciences is profound.

Recent advances in biotechnology and the recent progress in understanding the exotic chemistry of marine species suggest that the time is right for focusing greater attention on the development of living marine resources through biotechnology.

What little is known about the chemistry of marine animals and algae shows them to be rich sources of novel organic compounds and further indicates that marine microorganisms also are likely to be sources of useful new biochemicals or of industrial organics such as polysaccarides, hydrocarbons, organic acids, and alcohols. Marine microalgae may also produce high-value substances such as vitamins, pigments, steroids, or exotic hydrocarbons. The potential for research and development that could aid in meeting industrial requirements appears promising. Basic research in biochemical engineering is needed to form the

basis for large-scale cultivation of these organisms, while higher marine organisms or their cells will be needed to produce novel substances of scientific, medical, or commercial importance.

Marine bacteria and microalgae are most important candidates for exploitation in a number of ways that depend on their unique biochemical processes. For example, the nonphotosynthetic sulfur bacteria can oxidize hydrogen sulfide and other sulfur compounds for energy to convert carbon dioxide to organic matter. This suggests the industrial potential for their use in detoxification of industrial effluents containing hydrogen sulfide and carbon dioxide. Similarly, bacteria inhabiting environments near oceanic hydrothermal vents also exhibit unique biochemical properties with distinct membrane components that allow them to live at elevated temperature and pressure levels and under conditions that normally might be considered toxic. Research on the biochemical mechanisms by which they have adapted to their environment may allow application of these mechanisms and associated high temperature enzymes to production of chemicals on a large scale and also perhaps biodegradation of wastes.

With the increase of industrial activity in the EEZ, it is essential that we better understand the basic electrochemistry and biology of marine corrosion and bioturbation processes. Marine corrosion in its many forms is one of the most serious factors detracting from our ability to build structures in the EEZ that will remain durable and reliable for long periods of time. It is estimated that marine corrosion cost the United States about $12 billion in 1984.

Technology Needs

Powerful new technologies have become available for collecting data essential to producing bathymetric charts and assessing the nature of the seafloor. These include multi-beam bathymetric sounders, sophisticated multisensor deep-towed and untethered vehicles, sidescan sonars, and precise global positioning systems, which are as revolutionary to current charting practices as modern computers are to calculating machines. Some research vessels, both public and private, are being equipped with an arsenal of new equipment, such as additional Seabeam systems, sidescan sonars, Global Positional Systems, gravimeters, ocean floor camera systems, and others. Submersibles have proven to provide valuable and unique data resulting from direct *in-situ* observations, measurements, and sampling. The research submersible *Alvin* is presently being used to its operational capacity. Also, additional remotely operated vehicles, both tethered and acoustically controlled, are needed for EEZ research. Such research and development is underway in the private sector to meet these needs.

The petroleum industry has clearly demonstrated its initiative and willingness to conduct research and develop or adapt the technology uniquely required for the exploration and production of offshore oil and gas reserves. The industry has favorably responded to the charges of the Stratton Commission Report: ". . . it will be difficult but essential to establish a reasonable dividing line between what industry should do for itself under profit motivation and what government should do to assist. In most instances, programs that benefit only a specific industry more properly could be carried out by that industry. . . ." Nevertheless, both industry and the private sector share a major concern that EEZ environmental data bases be created and maintained for the prediction

of short- and long-term environmental trends (ecological, fisheries populations, etc.) and oceanographic and meteorological conditions, such as ice coverage, formation, and movement of ice, wind, wave and swell, internal wave structure and origin, mesoscale circulations, long-term deep-current profile, and foundation strength. The development of these data bases and the subsequent development of the assessment technology and predictive capability to make long-range predictions in climate, weather, or natural storm events will increase the safety of structures and the operations of any resource development project or program in the EEZ.

Information Management

Increased activity and assets in the EEZ require better prediction of environmental conditions, such as meteorology and the sea-air interaction, through the water column, to the water-sediment interface at the seafloor. EEZ related activities include accurate and timely forecasts, monitoring and predicting pollution dispersal, fishery research and assessment, and mapping and charting for offshore resource assessment and development.

Among the most valuable services provided to the public within the EEZ are those of weather, seastate, and ice forecasts. Without timely and accurate forecasts, lives are in peril and property at risk. Within the last decade, such dangers have markedly increased with the expanded exploration and development of offshore resources, particularly in the more hostile Alaskan waters. Advances in the science of weather prediction have not always kept pace with the need for accurate forecasts in remote offshore areas. Supplementing the satellite information used for forecasts are a series of weather data buoys deployed on the middle and outer continental shelves, which transmit real-time oceanographic and meteorological information. Both the satellites and the weather data buoys, however, have their limitations. The satellites are restricted to cloud-free conditions for certain monitoring, whereas the weather buoys are so sparsely sited that the data are often of more local than regional interest. Buoys also have the advantage of transmitting regardless of the weather condition. To compensate for a shortage of data buoys in the EEZ, fishermen in marine coastal areas have been asked to provide actual surface weather conditions. These at-sea observations are transmitted via radio to shore stations for subsequent transmission to the nearest National Weather Service forecast office, where they are integrated into the next forecast. This inexpensive program has resulted in weather forecasts of increased precision and resolution, but is restricted to those areas where vessels are working.

The Outer Continental Shelf Lands

For the past 30 years, the Secretary of the Interior has been responsible for administering the exploration and balanced development of Outer Continental Shelf (OCS) energy and minerals to achieve national economic and energy policy goals, assure national security, reduce dependence on foreign sources, and maintain a favorable balance of payments in world trade. Moreover, the role of the OCS in providing energy, raw materials, jobs, revenues, and

national security must be balanced with the needs for environmental protection and preservation.

Since the beginning of the OCS leasing program in 1954, through FY 1984, 86 OCS lease sales have been held. Of these, 81 were oil and gas lease sales, 2 were salt sales and 3 sulfur sales. The total bonus paid by industry for all leased tracts was nearly $51 billion; in addition, $23.8 billion was received in royalties during this 30-year period. In that time about 6.7 billion barrels of crude oil and condensate and 66.6 trillion cubic feet of natural gas were produced.[20]

In 1984, the nation's offshore oil and gas production represented about 12 percent or 380 million barrels of total domestic oil production and 25 percent or 4.6 trillion cubic feet of total domestic natural gas production. All OCS production came from the Gulf of Mexico and offshore California. It has been estimated that the U.S. will have to find some 32 billion barrels of new oil reserves during the next 10 years, just to keep domestic production at current levels. The OCS is predicted by many to contain over half of our future domestic petroleum production. These resources, however, can only be discovered by exploratory drilling and produced by subsequent development of those few successful wells. On average, some 85 percent of all exploratory wells are not successful. However, many productive oil regions, such as those in the North Sea, Prudhoe Bay, and the Rocky Mountain Overthrust Belt, were discovered only after many unsuccessful exploratory wells had been drilled.

New Leasing Procedures

In January 1984 the Secretary of the Interior refined leasing procedures and improved consultation procedures, as follows:

- The Secretary indicated his intent to make more key decisions in the fourth month of the leasing process when the area of leasing interest is defined for analysis and review in an environmental impact statement (EIS). This policy attempts to resolve state, environmental, and military conflicts much earlier in the planning process.
- Communication with the states has been strengthened. Specific actions taken include early scoping meetings, increasing the number of public hearings, and—even though prelease determination of lease sale consistency is not required—frequent consultation with the states concerning all issues, including anticipated issues of consistency with approved coastal management programs.
- To facilitate early balancing of hydrocarbon potential with environmental, economic, and defense interests, the oil and gas industry has been requested to provide more precise indications of its interest at the beginning of the leasing process.
- Decisions on the size and terms of each lease sale have been made on a case-by-case, sale-by-sale basis on the evidence available and in close consultation with the states.

The net effect of the Secretary's policy for improved consultation procedures has been deferral of about 47 percent of the area under consideration for leasing since January 1984. Yet OCS oil and gas leasing continued to be a major contributor to the federal treasury. Six OCS lease sales were held in which over

154 million acres were offered for lease, and 1,408 new leases were awarded for bonus bids that totalled over $4 billion.

Environmental Studies Program

Over the past decade, the Department of the Interior, in consultation with numerous other agencies, has spent over $370 million on an environmental studies program to ensure the protection of the multiple-use resources of the OCS. With its inception in 1973, the studies program primarily supported planned meetings, information syntheses, and prelease field work in all areas on the OCS leasing schedules. This information has been used in the analysis of risks and benefits of OCS leasing as well as in the development of sale-specific and programmatic Environmental Impact Statements, National Environmental Policy Act (NEPA) documents, and other decision papers. By 1980 most lease areas had multiple years of study data, and opportunities to focus on issues more related to postlease management decisions became available.

Extensive monitoring programs for long-term biological and chemical effects of exploratory and development activities were initiated on Georges Bank, Southern California, and deeper waters of the Mid-Atlantic. Numerous studies on endangered species (whales, seals, sea otters, seabirds, and marine turtles) were also initiated, as well as significant field and theoretical studies on physical processes and factors affecting the distribution and fate of materials introduced into the ocean.[21] The information from these studies is used in postlease determinations on the effectiveness of stipulations to protect the environment under such requirements as the Endangered Species Act (ESA), the Marine Mammal Protection Act (MMPA), and the National Pollutant Discharge Elimination System (NPDES).

Under national coordination by the Washington Office, continuing and new studies are being conducted throughout the U.S. OCS by the Atlantic, Gulf of Mexico, Pacific, and Alaskan regional OCS offices.

Studies in the *Atlantic OCS Region* include the reconnaissance of biological communities and physical processes occurring in the deep waters above the continental slope and rise to provide critical information for assessing and mitigating the effects of OCS operations in these areas. Monitoring programs on Georges Bank and the Mid-Atlantic are providing significant information concerning the effects of recent OCS oil and gas exploratory drilling. New information on marine mammals and turtles concerning effects of oil and behavioral response to oil spills is being provided by ongoing studies.

The studies program in the *Gulf of Mexico OCS Region* supports a multiple-year effort to define pollutant transport mechanisms over the continental slope and rise. This effort, a combination of physical oceanography, meteorology, and biological process studies, will provide critical input to oil spill trajectory analyses needed for anticipated future sales in deeper Gulf waters. The studies program is also continuing to support deep water biological reconnaissance studies to provide new information to assess and mitigate potential OCS operations effects. New initiatives to determine possible wetlands losses from OCS development are underway.

In the *Pacific OCS Region*, a major study of pollutant transport mechanisms off central and northern California is being conducted. Resulting data will be

used as input to oil spill trajectory analyses and risk assessments. A Southern California monitoring program, initiated in 1983, continues to collect long-term data on biological communities and chemical parameters. Another multi-year study started in 1983 is investigating recovery of rocky intertidal communities following natural and man-induced disturbances. Also, California sea otters are the subject of a study designed to define effective mitigating measures in the event of an oil spill.

Studies in the *Alaska OCS Region* address a variety of topics including the effects of OCS operations on native and nonnative communities, commercial and subsistence species, and endangered species. Extensive studies on the bowhead and other whales continue in the Bering, Chuckchi, and Beaufort Seas. Sea ice hazards to OCS operations, the environmental transport of spilled oil, and models of possible marine mammal/oil spill interactions are physical process topics under study. In 1984 a seabird monitoring study in the Bering Sea and monitoring of trace metals and hydrocarbons in sediments and biota of the Beaufort Sea were initiated.

OCS Safety Record

Public perception of offshore oil and gas exploration and production activities remains heavily influenced by the 1969 Santa Barbara blowout in which approximately 30,000 barrels of crude oil were spilled. Although the spill occurred 15 years ago and caused no long-term environmental effects, that event had important consequences. Starting in 1970, many new safety procedures were implemented, and only 831 barrels of oil have been lost from blowouts nationwide since 1970. The overall environmental safety record of OCS operations is excellent. Since 1969 over 4.7 billion barrels of crude oil have been produced in U.S. offshore waters without a major spill reaching shore. Between 1975 and 1982 spillage from offshore operations was less than one barrel per 125,000 barrels produced. In 1984 only 629 barrels of oil were spilled in connection with exploration and production of offshore petroleum. The 1984 spills were 432 barrels less than those in 1983. By comparison, natural seeps along the California coast discharge 18,000 to 277,000 barrels of oil every year, according to the California State Lands Commission, and the tanker *Alvenus* lost over 35,000 barrels when it went aground off Louisiana in 1984. The National Academy of Sciences reported in 1981 that on a worldwide basis, only about 5 percent of the oil pollution in the oceans is from offshore oil and gas production.[22]

The Federal Mineral Estate

The public lands are an important source of the nation's mineral and energy resources, some of which are critical and strategic. Following President Reagan's April 5, 1982, report to Congress, in which he submitted the National Materials and Minerals Program Plan, the Bureau of Land Management (BLM) developed the first Mineral Resources Policy statement in the agency's history. That statement recognizes the role of private enterprise in the development of a stable domestic minerals industry and the orderly and economic development of

domestic mineral resources. The BLM is responsible for making public lands available for these purposes, while adhering to principles of balanced multiple-use management.

Of the approximately 600 million acres of the federal mineral estate administered by the BLM, 130 million acres are under lease for oil and gas exploration. More than 150 million barrels of oil and 1.1 trillion cubic feet of natural gas (almost 6 percent of U.S. consumption) are produced annually from the almost 50,000 producing wells on these lands. There are 628 federal coal leases covering 944,550 acres. More than 100 million tons of coal, large amounts of metals, and lesser quantities of potash, sodium, sulphur, uranium, and valuable minerals are also produced from the public lands.

Geology and Mineral Resources

To assure integrity of the oil and gas leasing program, BLM has fully implemented the existing classification standards and initiated an accelerated review of all producing areas to determine which lands should be leased competitively as Known Geologic Structures (KGS). BLM also has developed new standards for classifying lands valuable for other minerals.

During fiscal year 1984, 4.64 million acres were added to KGS lands, bringing the national total to 28,901 million acres classified for competitive oil and gas leasing. Classification actions involving federal geothermal lands resulted in the addition of 84,165 acres to Known Geothermal Resource Areas (KGRA) and the deletion of 70,193 acres from existing KGRAs, giving a net increase of 13,972 acres.

Oil and Gas Management

The Mineral Leasing Act of 1920 gives BLM responsibility for oil and gas leasing on about 600 million acres of public lands and national forests, acquired land, and private land where mineral rights have been retained by the federal government. Both competitive and noncompetitive oil and gas leasing are covered in the Act.

During fiscal year 1984, an approximate total of 7,500 leases covering 10.6 million acres were issued, including 900 leases covering 400,000 acres issued by competitive bidding, 2,400 leases covering 4.7 million acres by over-the-counter leasing, and 4,300 leases covering 5.5 million acres issued under the simultaneous oil and gas leasing system.

As of January 1, 1984, an estimated 148,466 oil and gas leases were supervised by BLM on federal and Indian lands, of which 19,336 were producible. Approximately 20 percent of the producible leases and 10 percent of the total leases are on Indian lands.

During fiscal year 1984, approximately 2,000 operators were engaged actively in producing oil and gas from onshore federal and Indian leases located in 26 states. A total of 4,479 applications for permits to drill were filed for oil and gas wells, and 4,231 were processed. Current statistics indicate that over 2,000 new oil and gas wells were completed for production on federal and Indian lands.

Geothermal Management

The Geothermal Steam Act of 1970 provided BLM authority to issue leases on public, withdrawn, and acquired lands administered by the Departments of the Interior and Agriculture. During fiscal year 1984, approximately 53,000 acres within known geothermal resource areas received high bonus bids of $539,000. A total of 5.9 million acres have been leased for geothermal development since the program began in 1974. At the end of fiscal year 1984, 1,608 geothermal leases were in effect, of which 30 were capable of production and 12 actually were in production.

Coal Management

In the western United States, as much as 60 percent of the coal resource is owned by the federal government. Major reserves are found in Colorado, Montana, New Mexico, North Dakota, Utah, and Wyoming. By the end of fiscal year 1984, a total of 628 coal leases were outstanding on federal lands, covering 944,550 acres and containing an estimated 17.6 billion tons of recoverable reserves of coal.

The current federal coal management program utilizes a sequential process, emphasizing land use planning, surface owner consultation, and activity planning for leasing. Continued substantial input from industry, other federal agencies, state and local governments, and the public is an essential and integral element of the program.

Coal management also incudes leasing by application within federal coal regions under emergency conditions (e.g., where federal coal would otherwise be bypassed) and outside federal coal regions where regional competitive leasing is impractical.

Through the lease by application component of the program, four lease sales were held, and six new leases covering about 70 million tons of recoverable reserves were issued during the fiscal year. No preference right lease applications (PRLAs) were processed to completion. Six previously rejected PRLAs were reinstated by the Interior Board of Land Appeals, and 14 PRLAs were relinquished, resulting in a total number of 123 pending PRLAs.

Final regional coal Environmental Impact Statements (EISs) were filed with the Environmental Protection Agency for the Southern Appalachian-Alabama Subregion, San Juan River in New Mexico, and Uinta-Southwestern Utah Regions. Additionally, draft EISs for the Green River-Hams Fork and Powder River Regions were completed and released for public comment. However, regional lease sales scheduled in fiscal year 1984 for these five regions were postponed pending action on program revisions directed by the Secretary as a result of two congresssionally directed federal coal program reviews.

Linowes Commission

The first of these reviews was initiated in August 1983, when the Secretary of the Interior appointed a Commission on Fair Market Value Policy (the Linowes Commission), pursuant to Public Law 95–63, to study the federal coal management program and make recommendations to improve Interior's leasing

procedures. In November 1983 Congress imposed a moratorium on coal lease sales until 90 days after the Commission published a report of its findings and recommendations. The Commission's report, *Fair Market Value Policy for Federal Coal Leasing*, was made available to Congress and the Secretary of the Interior in February 1984. It contained 36 recommendations and several judgments and conclusions.

In a separate but related action, Congress directed a second review by the Office of Technology Assessment (OTA) to provide an assessment of the federal coal program's ability to ensure the development of coal leases in an environmentally acceptable manner. The OTA's report, *Environmental Protection in the Federal Coal Leasing Program*, which contained 10 policy options for improving program effectiveness, was submitted to Congress and the Secretary in May 1984.

The Secretary has responded to both the Linowes Commission and the OTA reports (*Review of Federal Coal Leasing* of March 19, 1984, and *Review of Planning Considerations in Federal Coal Leasing* of July 19, 1984, respectively), accepting most of the recommendations and policy options. Through BLM, the Department is developing rules, procedures, and guidelines to implement 35 of the 36 Linowes Commission recommendations and the 10 OTA policy options. The Department expects to have in place a decision-making process that will allow consideration of regional coal leasing by fall 1985 if Regional Coal Team recommendations advocating sales are forthcoming. (Regional Coal Teams are composed of representatives of the BLM and of all governors representing the states within that coal-producing region.)

Oil Shale/Tar Sand Management

BLM manages more than 80 percent of the estimated oil shale reserves in the 25,000-square mile Green River formation in Northwestern Colorado, Northwestern Utah, and Southwestern Wyoming. The formation contains a total estimated potential of almost two trillion barrels of shale oil, of which an estimated 731 billion barrels are commercially developable.

In continued support of the permanent oil shale program, BLM is preparing EISs and resource management plans (RMPs) in the oil shale areas of Colorado and Utah. These plans, to be completed in fiscal year 1985, will identify multiple uses of the federal resources within the planning boundaries. Among the identified multiple uses will be priority management areas for oil shale development. Wyoming RMPs in oil shale areas are scheduled for completion in fiscal year 1987.

About 70 percent of the nation's tar sand deposits are estimated to be in Utah, principally on federal lands. Current estimates are that two billion barrels are deemed recoverable with today's technology. Approximately 100 to 200 million barrels can be recovered by surface mining; the rest probably will require some form of *in situ* techniques.

Non-Energy Mineral Leasing

Public lands are an important source of several non-energy minerals, for example, sodium, phosphate, potassium, lead, and zinc. On May 25, 1984

revisions to the mineral leasing regulations (43 CFR 3500) became effective after a long-term, comprehensive analysis of public comments on the 1982 draft version. The revisions included provisions that streamlined the processing of prospecting permits and lease applications, defined "valuable deposit" and "chiefly valuable" among other terms, and added new provisions for exploration and development of hardrock minerals.

The majority of the non-energy mineral leases include copper, lead, zinc, phosphate, potash, sodium, and sand and gravel. Of these minerals, there were 104 producing non-energy mineral leases, 95 active mine work leases, 19 exploration leases, and 12 development leases for BLM to monitor in fiscal year 1984. A few leases for other minerals, including iron ore, molybdenum, barite, quartz, feldspar, fluorspar, and wavellite, among others, also exist.

Safe Management of Nuclear Waste

Today, in the United States, there are no facilities for the permanent disposal of the highly radioactive waste[23] generated during the production of electricity in nuclear power plants or during the production of nuclear materials for national defense. Although nuclear activities produce small volumes of wastes in comparison to other activities that generate hazardous wastes, since nuclear wastes are radioactive, they therefore require special handling and storage. While such wastes have been safely stored for decades with no discernible adverse effects on the health and safety of the public, some part of them will remain somewhat radioactive for thousands of years.

A safe and environmentally acceptable method of permanent disposal was needed to deal with the accumulation of radioactive wastes. To address this need, Congress passed the Nuclear Waste Policy Act of 1982, which was signed into law by the President on January 7, 1983. The key feature of the Act is the provision for the development of deep geologic repositories for the disposal of high-level radioactive waste and spent nuclear fuel. The Act specified a schedule and a step-by-step process by which the President, the Congress, the states, affected Indian tribes, local governments, and federal agencies must collaborate in the siting, design, construction, and operation of the geologic repositories. The Act has provided a mandate and a set of rules—including unprecedented interaction among the federal government, the states, and the public—for proceeding with this program.

Nuclear Waste Generation—The Process

In 1984, 86 domestic nuclear power plants generated more than 13 percent of the electricity produced in the United States. With this level of production, nuclear power became the second leading energy source of electricity generation in the United States, following coal. Another 30 nuclear plants are either under construction or planned. Recent government studies predict that nuclear power will play an expanding role in the supply of electricity in this country and will generate about 20 percent in the 1990s.[24] However, the growth of the nuclear power industry beyond the 1990s is uncertain for a variety of economic and institutional reasons.[25]

For each large nuclear power plant, about 33 tons of uranium oxide fuel, which has been gradually irradiated during the fission process, are removed from the power plant reactor each year. At this point the fuel can no longer sustain an efficient chain reaction and is extremely radioactive and thermally hot. It is referred to as "spent fuel."

The nuclear fuel is the heart of the reactor. The fuel consists typically of pellets of ceramic uranium oxide that is sealed in hundreds of metal rods bundled together within a very strong, rigid metal structure called a "fuel assembly." The fuel rods are carefully spaced in the fuel assemblies to allow coolant (water in most cases) to flow between them. Each assembly is about 12 to 14 feet long and weighs about 1200 pounds. Fuel assemblies are designed to be readily handled with suitable hoists and cranes at the reactor site.

Several hundred fuel assemblies are closely packed vertically into what is called the "reactor core." It is designed to withstand very high pressures and temperatures. In large reactors, as much as one million liters of water flow through the reactor core every minute.[26] The water, which is recycled, also acts to moderate the fission process—an essential design feature of nuclear reactors.

Spent fuel assemblies that are no longer suitable for operations in the reactor are removed and stored in a deep water pool adjacent to the reactor. The water cools the spent fuel, which is thermally hot, and serves as an effective shield to protect workers at the reactor site from high energy gamma radiation. The water is kept free from minerals that would corrode the fuel rods. It remains in that storage pool and is not discharged, although it is replenished and filtered.

The level of radiation within the fuel assemblies begins to decline immediately after their removal from the reactor core, and within 10 years it has decayed by 90 percent.[27] Nevertheless, technicians constantly inspect the spent fuel assemblies to ensure safety. Storage of spent fuel in water basins is a temporary measure; that fuel will ultimately be shipped to geologic repositories for permanent disposal.

From the late 1950s through the end of 1984, spent fuel assemblies containing about 10,000 metric tons of uranium (MTU) have been "discharged" (taken out of service) from commercial nuclear power plants. This quantity of discharged fuel would be approximately equal to the volume of one football field three feet deep—a relatively small size. The inventory of spent fuel will grow and may approach 130,000 metric tons by the year 2020. This amount is still very small in comparison with the wastes from coal-burning electricity generation plants. A single, modern coal-fired electricity plant, for example, produces hundreds of thousands of tons of ash, gases, and sludge each year that must be properly controlled and disposed of in accordance with strict environmental regulations.

A small quantity of liquid high-level radioactive waste was generated during the commercial reprocessing of reactor spent fuel at a facility near West Valley, New York, from 1966 through 1972. (Reprocessing is a chemical separation process that can extract plutonium, which is created during the fission process, and the remaining usable uranium from spent fuel rods. These energy containing elements can be fashioned into new fuel assemblies for reinsertion into reactors to produce more energy.) This liquid waste is scheduled to be solidified into glass and encapsulated in stainless steel canisters for eventual disposal in a geologic repository along with the spent fuel assemblies.[28]

Defense high-level radioactive waste (DHLW) is produced by the nation's atomic energy defense activities. It includes the highly radioactive waste material that results from the reprocessing of specially designed and irradiated nuclear fuel to obtain nuclear materials for weapons. Defense high-level waste is generated and stored at three U.S. Department of Energy (DOE) sites: the Savannah River Plant (South Carolina), the Idaho National Engineering Laboratory (Idaho), and the Hanford Site (Washington).

At the Savannah River Plant, defense high-level radioactive waste is stored in underground tanks. That waste will be converted to a final waste form (i.e., borosilicate glass), starting in 1989. This waste form will be encased in metal canisters and stored at the site until a geologic repository becomes available to receive and dispose of the waste. High-level waste at the Hanford site is also stored in underground tanks. As called for in the Department's published Defense Waste Management Plan,[29] both new waste and readily retrievable older waste at Hanford will be processed in an immobilization plant. The immobilized waste will be stored at that site until it is shipped to a repository for permanent disposal. High-level liquid waste at the Idaho National Engineering Laboratory has been converted to a dry powder and is stored in stainless-steel bins in underground concrete vaults. The Department's program plan calls for a waste immobilization facility at the Idaho site to begin operations early in the next century.

Both spent fuel and liquid radioactive waste from reprocessing contain products from the fissioning process in nuclear reactors that remain radioactive, and, hence, require isolation for very long periods of time. It is for this reason that the federal government seeks to implement a permanent, viable solution to the waste disposal problem.

A National Policy for Managing Nuclear Waste

The search for a permanent solution to the problem of radioactive waste disposal spans nearly three decades and embraces a variety of containment and disposal alternatives. The question of what to do with highly radioactive nuclear wastes was approached initially from three perspectives:

- Should it be held until its radiation decays to natural levels?
- Should it be diluted and dispersed?
- Should it be concentrated and contained?

Numerous alternatives were examined, including, for example, deep geologic disposal, disposal beneath the seabed, disposal in outer space, and ice-sheet disposal. As the boundaries of knowledge expanded, an increasing confidence in geologic disposal developed. Today, the majority of informed technical opinion holds that disposal of concentrated and contained nuclear waste in deep, stable, geologic repositories is the preferred method of permanent isolation.

A national policy for the management of nuclear wastes has emerged over the decades. National programs for nuclear waste management that had operated under very general guidelines from Congress became focused in the 1970s and early 1980s. President Reagan's "Nuclear Policy Statement" of October 8, 1981 contributed significantly to the forging of a national consensus on the policy for safe radioactive waste management. Designed to "correct present government deficiencies and to enable nuclear power to make its essential

contribution to our future energy needs," the policy statement outlined a number of specific objectives designed to expedite resolution of the problems associated with nuclear waste managment. This Presidential initiative was part of a bipartisan effort that led to the passage by Congress, on December 20, 1982, of the first comprehensive legislation for the management of high-level waste in the history of the United States.

The Act establishes a rigorous and complex set of tasks for the ultimate disposal of nuclear wastes in geologic repositories. Successful implementation of the Act requires the resolution of substantial technical and institutional challenges. First, the public must be convinced that the interests of the nation are best served by consolidating radioactive waste now stored temporarily at nearly 100 sites around the country into a limited number of geologic repositories designed for permanent disposal. Next, the Department must demonstrate to the citizens of the country that the waste disposal program will be safe, efficient, and timely. Furthermore, the Department must balance conflicting and competing interests, as reflected by the tension between a rigorous, mandated program schedule and the need for extensive public and community involvement.

The Act requires the DOE to site, obtain a license from the U.S. Nuclear Regulatory Commission (NRC), construct, and operate geologic repositories for spent fuel and high-level waste in a manner that "will provide a reasonable assurance that the public and the environment will be adequately protected. . . ." In addition to establishing a detailed schedule for the siting and licensing of one or more geologic repositories, the Act contains several other features, including the following:

1. Assigning responsibility for the full payment of disposal costs to those who benefit from those services (i.e., the owners and generators of high-level waste and spent fuel) and, accordingly, creating in the U.S. Treasury a special Nuclear Waste Fund to be composed of the payments made by those using the services. These user fees are paid by ratepayers who use nuclear-generated electricity.
2. Committing the federal government to study monitored retrievable storage in parallel with permanent geologic repositories.
3. Providing for a federally owned and operated system of interim storage facilities for no more than 1900 metric tons of spent fuel from civilian reactors whose owners cannot reasonably provide adequate storage capacity at the reactor site and creating an Interim Storage Fund to make certain that those using the services will pay the full cost.
4. Setting out an extensive system of checks and balances through public involvement, along with written consultation-and-cooperation (C&C) agreements, to ensure federal accountability to and communications with states, affected Indian tribes, and the public.

The year 1984 was the first full year during which the civilian radioactive waste management program was conducted by the DOE office established by the legislation to administer the program.

The Geologic Repository Program

Each of the two geologic repositories planned by the Department's Office

of Civilian Radioactive Waste Management (OCRWM) will resemble a large mining complex.[30] The repository will combine two types of industrial facilities—a nuclear waste processing and handling facility at the surface, and a large mine constructed 1,000 to 4,000 feet below the surface. The repository underground area, which is designed primarily for the emplacement of 70,000 metric tons (uranium) of spent fuel, will cover approximately 2,000 acres. Above the ground, a central area of about 400 acres will contain a variety of buildings and structures that will be used during the operations period of the repository, which should be about 30 years. Rail and truck unloading areas, warehouses and administration buildings, water treatment plants, a storage area for excavated rock, and other facilities will comprise the central complex, in addition to the waste handling building. A restricted, surface zone slightly larger than the area of the underground repository will be established. After operations have ceased, each of the two repositories will be sealed and decommissioned, with all reasonable efforts taken to alert future generations of its existence. Certain activities will be prohibited at the site, with highly visible markers denoting such prohibitions. The Department of Energy is investigating a range of possible measures, in addition to the markers, that could be used to inform future generations about the repository while the emplaced radioactive waste decays to safe levels.[31]

The process of selecting a suitable site for each repository is both dictated by the requirements of the NWPA and influenced by the extensive research and development activities that preceded enactment of that legislation. Hundreds of factors have entered into DOE's search for an accceptable first repository site. These included, in the broadest sense, the types of geologic formations to be considered, the geologic history of those formations, the public safety and socioeconomic concerns, and the environmental consequences. Based on lengthy analyses of these factors, DOE, in February 1983, identified nine potentially acceptable sites in six states for the first repository. These sites are located in the following geologic formations:

- Salt – natural sodium chloride in rock form;
- Basalt – solidified volcanic lava;
- Tuff – solidified volcanic ash deposits.

These initial selections were fundamental to DOE's decision, in December 1984, to propose three of these sites as the preferred ones for recommendation to the President for site characterization. These sites are:

- Nevada – Yucca Mountain site – Tuff geology;
- Texas – Deaf Smith County site – Salt geology;
- Washington, DOE Hanford Reservation site – Basalt geology.

The first repository is scheduled to begin operations by no later than January 31, 1998. The second repository would commence operations early in the next century. However, the host state or any affected Indian tribe may issue a notice of disapproval regarding construction authorization for a repository. The Act allows for a Congressional override in the event a site previously recommended by the President is vetoed by any affected party. The Department of Energy is striving to develop a credible, technically sound program that will gain the support of all parties involved.

Although the Act stipulates the schedule and conditions of the site-selection process, public perception of the benefits and weaknesses of a geologic repository

to contain radioactive wastes could be expected to influence the government's decisions. For example, opponents of geologic disposal have questioned the technical judgments made by DOE to support its proposed site recommendations. Among other things, they are worried about possible migration of radionuclides in the event the repository surroundings are breached. DOE is addressing this problem by adopting a conservative, multibarrier approach to containment that consists of the waste package itself, the repository structural configuration, and the adjacent host geology. These barriers are designed to arrest any migration of radionuclides and prevent them from following pathways to the biosphere.

Since the proposed sites are situated in sparsely populated areas of the country, the construction and operation of a repository over extended periods of time are likely to induce both economic prosperity and hardship. The rapid infusion of capital and labor could produce disruptive social change, as well as enhance the economic viability of the areas. The Act calls for the Department to: (1) assess the potential socioeconomic impacts of the repository; and (2) provide financial and other assistance to alleviate adverse impacts, should they occur.

In recognition of these concerns and in response to the requirements of the Act, the Department of Energy is seeking to enter into consultation-and-cooperation (C&C) agreements with eligible states and affected Indian tribes. These C&C agreements are intended to address areas of mutual concern, such as public health and safety, joint surveillance and monitoring of project activities, public education programs, conflict resolution, and financial and other assistance.

The Office of Civilian Radioactive Waste Management (OCRWM) has also embarked upon a dedicated public "outreach" program that goes beyond the public affairs functions normally associated with other government programs. Early, frequent, and meaningful citizen involvement is the hallmark of OCRWM's emerging outreach program. In fact, the implementation of this program marks one of the major accomplishments of 1984.

Disposal of Defense-Generated Nuclear Waste

Section 8 of the Act requires the President to evaluate the feasibility of combining defense-generated high-level radioactive waste and commercial waste in one or more geologic repositories. Based on an in-depth evaluation conducted by DOE, the President, on April 30, 1985, advised the Secretary of Energy that he found no basis to conclude that a defense-only repository is required.[32] The full costs associated with placing defense waste in a commercial repository will be paid by the federal government into the Nuclear Waste Fund. Negotiations are underway between the OCRWM and the Department's Office of Defense Programs to ensure that the costs of a defense-commercial nuclear waste repository are equitably distributed.

The Transportation Program

The capability to transport spent nuclear fuel and high-level radioactive waste safely and economically is critical to the implementation of the waste management program. This capability is contingent upon the availability of appropriate

types and quantities of equipment and a stable regulatory and institutional environment.

Present plans call for the shipment of spent fuel from reactor sites to DOE facilities principally by rail and truck carriers. Spent fuel will be transported in casks licensed by the U.S. Nuclear Regulatory Commission. Three to 10 shipments a day of spent fuel from the storage sites to the repositories are envisioned once the system of two repositories achieves full operational status.

Institutional issues have surfaced as a major concern in the establishment of a safe and efficient transportation system. One of the major achievements of 1984 was the preparation of a draft transportation business plan. This document will be a companion piece to the transportation institutional plan, which will address such issues as prenotification to state and local governments of route selection, emergency response procedures, liability in the event of accidents, and the quality of the rail and highway system.

The Monitored Retrievable Storage Program

The Department of Energy is evaluating the role of integrated monitored retrievable storage (MRS) facility to improve waste management systems operations. The proposed MRS facility, which would be licensed by the NRC, would receive, consolidate, package, and subsequently store spent fuel assemblies in either sealed storage casks or dry wells before they are shipped to geologic repositories for disposal. Those packaged spent fuel assemblies would be sent directly to a repository by rail. This facility would serve as a logistics hub for the transportation system, increase the flexibility of the waste management system by providing a buffer between the acceptance of nuclear waste and its emplacement in the geologic repository, simplify the design, construction, and operation of repository facilities by controlling the flow of spent fuel to the repository, and provide a focal point for system integration activities.

In January 1986 the Secretary of Energy will submit to Congress a proposal for the construction of one or more facilities. Most of the relevant activities in 1984 were directed to the development of MRS facility designs and to deployment planning. The site-screening process entailed the development of screening factors that could be used to evaluate siting of the MRS facility. Such screening factors as meteorological conditions, potential geotechnical site conditions, simplicity of construction at the site, and the proximity of the site to existing interstate highway and railroad networks were used to narrow the range of possible candidate sites for the MRS facility, leading to the Department's announcement, in April 1985, of three potential candidate sites. The preferred site is located at DOE's site of the cancelled Clinch River Breeder Reactor project, near Oak Ridge, Tennessee. The alternative candidate sites are DOE's Oak Ridge federal reservation and the Tennessee Valley Authority's cancelled nuclear powerplant site at Hartsville, Tennessee.[33]

The Interim Storage Program

For utilities unable to provide adequate at-reactor storage capacity for their spent fuel assemblies prior to 1998, the Department is authorized to provide interim storage of up to 1,900 metric tons for such nuclear waste, provided that

NRC rules favorably on the application for assistance submitted by the particular utility. DOE has drafted a standard service contract and has established a relevant fee payment schedule for the potential users of this federal service, but such contracts must be entered into before January 1, 1990. Current spent fuel inventory and storage projections indicate little, if any, immediate demand for federal interim storage. Hence, the Department has not activated the Interim Storage Fund, nor does it expect to do so.

The Nuclear Waste Fund

Section 302 of the NWPA stipulates that the owners and generators of the nuclear waste who entered into service contracts with the federal government will pay the full costs of waste disposal, which are estimated to be in excess of $23 billion (in 1984 dollars). To cover the costs for disposing of commercial spent nuclear fuel, utilities with nuclear power plants are obliged to pay two fees—one for electricity produced by nuclear power on or after April 7, 1983, and another one for spent fuel discharged prior to April 7, 1983. The former fee was set initially by the Congress at 1.0 mill per kilowatt-hour, while the latter one-time fee was in the form of dollar per kilogram charges that equate to 1.0 mill per kilowatt-hour.

The major source of funds for the waste disposal program is the ongoing fee, which is a constituent part of the Nuclear Waste Fund. Revenues from the collection of the ongoing fee are rising steadily as new power plants become operational. Current revenues exceed $300 million a year; and they are expected to reach $500 to $600 million annually within a few years. The one-time fee comprises the other component of the Nuclear Waste Fund. DOE estimates the one-time fee will eventually produce revenues of over $2.3 billion. Utilities have a choice of three payment options in deciding which payment method to adopt: (1) A utility could elect to pay over a period of 40 quarters, with interest, from April 7, 1983, as long as the last payment is made before the first delivery of spent fuel to DOE. (2) A utility could elect a single payment prior to the first delivery of spent fuel, plus interest. (3) A utility could pay in full before June 30, 1985, with no interest.

Provisions of the Act require the Secretary of Energy to review annually the user fees to determine if they cover program costs. The Department has published three Nuclear Waste Fund (NWF) fee assessment reports since 1983. The latest report, published in February 1985, concluded that the current fee of 1.0 mill per kilowatt-hour is adequate at this time for a reasonable range of program costs, nuclear generation, and economic forecasts.[34]

Enactment of the Nuclear Waste Policy Act of 1982 represented the culmination of an extended national effort to resolve the problems associated with the management of nuclear waste. The responsibilities vested in the U.S. Department of Energy to develop a cogent, technically sound, and environmentally acceptable waste management program are significant, and the strategy adopted by the Department reflects this. The Department is progressing with a program that accords with the goals of the legislation, particularly as they relate to the involvement of the public and other affected parties.

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Chapter 9

Special Report: The Public Benefits of Private Conservation

"Since there are countless ways to go wrong, but only a very few ways to do right, our best chance to deal successfully with our contemporary problems and those of the future is to learn from the success stories of our times." (René Dubos)

The 14th Annual Report of the Council on Environmental Quality, *Environmental Quality 1983*, for the first time since 1971 included a section on private sector programs and activities. The Report stated:

"Traditionally, the annual report of the Council on Environmental Quality has looked at environmental and natural resource issues from the federal government's perspective . . . . While the federal government's role in this area is essential, the important contributions made by other public and private organizations cannot be overlooked. . . .

"For this reason, the Council has included in this report an overview of nonfederal environmental expertise and experience that has developed in a comparatively quiet fashion over the last decade. . . ."

This chapter presents some of the findings of a more detailed and systematic inventory that examines the contributions of the private sector to the conservation and protection of America's unique natural heritage. The inventory considers the efforts of both nonprofit and profit-seeking organizations to protect and preserve natural resources, wildlife, habitat, areas of unique natural and biological diversity, and natural sites, vistas, and open areas. It is an attempt to find out what the private sector is doing, how it is doing it, and why it is being done. It is an attempt to discover how and to what extent private initiatives complement the efforts of a variety of governmental agencies to protect the nation's natural resources. What emerges is a picture of how private lands provide public amenities.

The Public Domain

Although the United States has some one-third of its entire land area in federal ownership, and about 40 percent in government ownership at all levels, it is important to recognize that most of the federal estate is located in Alaska and the 11 conterminous western states. Throughout the Great Plains and the East, only about 4 percent of the land is owned by the federal government. Thus, the preservation of the public domain lands, while important, will likely not be sufficient to preserve considerable amounts of America's flora and fauna and wealth of biological diversity over time; the contribution of private

land ownership to the protection and preservation of natural resources becomes critical.

Much of the public land, while incomparable in scenic and natural splendor,is relatively sparse as a pool of biological and genetic diversity. While a number of important and unique species are found there, these were "the lands that nobody wanted." The vast extent of the Bureau of Land Management's holdings in the West are generally arid, dominated by sagebrush and a few other species, and are relatively impoverished in wildlife. Many of the extensive areas of national forests in the West are also characterized by relatively few plant and animal species. While these areas and the western desert lands are an important part of the nation's natural heritage, their relative contribution to the protection of America's wildlife is disproportionately small.

Often the choicest areas in the West were the lands with water. The stream bottoms, the wetlands, the springs, etc., were among the major areas that somebody wanted and that were homesteaded by private citizens. They were also the most biologically rich and important.

Furthermore, much of the wealth of wildlife species on the public lands is located in national parks and especially in the national wildlife refuges. These areas in particular, however carefully protected, may face long-term problems associated with fragmentation of biological preserves. For instance, can the unique tropical ecosystem of the Everglades National Park and its association of water-dependent plants and animals withstand the continued growth and development of South Florida, the diversion and restriction of water flows into the park, and the developmental pressures abutting the buffer zones surrounding the park? While once much of South Florida was a natural extension of the Everglades, the park is now essentially an island ecosystem—no matter how large. The same questions can be asked about other preserves and refuges scattered throughout the country. Can isolated pockets of prairie chickens survive amidst a sea of corn and soybeans if there are no avenues for these populations to avoid genetic inbreeding? If all of our parks and refuges become isolated island ecosystems or refugia, will much of our present wildlife heritage still exist in the next century?

Increasingly, biologists and ecologists have come to recognize the importance of finding methods to encourage the maximum amount of preservation of habitat and wildlife on all remaining lands not protected and owned by government agencies. However, it is neither possible nor desirable that the government own all of the land, or protect all of our nation's natural and environmental diversity. Shifting economic priorities, government deficits, and greater demands for a lessening of the tax burden on the private sector all suggest that the policies of recent decades, of primary reliance upon the public sector to protect and preserve the country's natural resources, will no longer be sufficient to the task. We will have to rely heavily upon private landowners and organizations to play a greater and greater role in protecting these resources.

Thus, a necessary starting point is to determine what is already being done. These efforts can be expected to guide policy-makers in finding ways and incentives to encourage still further those activities of the private sector that protect and preserve the nation's natural resources.

Privately Owned Lands

The land east of the 100th meridian, which is mainly in private ownership, faces potential difficulties for natural resource conservation. This land contains most of the cropland in the nation and much of its private, non-industrial timberland. States such as Illinois and Iowa, the two most intensively farmed states in the nation, have more than 70 percent of their land in crops. Modern intensive farming practices that replace more diverse native flora with a monoculture lead to loss of wildlife habitat and indigenous wildlife species.

Furthermore, most of the more densely populated states and many of the greater urban areas are located in the East. Thus, it is all the more urgent to determine what contributions the private sector has made and is making in these areas to the conservation of natural resources and the protection of wildlife and its habitat.

Has the dawning of a national environmental awareness altered the way in which the private sector approaches the protection of natural amenities? Are there incentives waiting to be discovered or employed which will encourage the private sector to undertake a greater role in the cooperative task of saving our heritage for tomorrow? Are there disincentives and perverse incentives and policies which can be eliminated or altered to help protect our resources? Can changes be made on the margin, without the need of undertaking vast and expensive programs, to encourage the private sector to undertake expanded efforts to preserve our natural environment?

These are important questions. Many of them go far beyond the task and scope of this inquiry. Yet they underscore the necessity of beginning a study of what the private sector is accomplishing, of publicizing and encouraging these activities, and especially of ending the fruitless and often acrimonious polarization that has colored so much of the environmental debate of the past 15 years and hindered the common goal and task of all Americans to protect and preserve our unique natural heritage, while enjoying a maximum degree of personal freedom, a comfortable and healthful standard of living, and a clean and safe environment.

We are generally aware of the status of natural resources, particularly wildlife and habitat, on federal and state lands. These lands are well protected, managed, studied and inventoried by government biologists, wildlife managers, game wardens, and private scholars. In addition, since the passage of the Endangered Species Act, increasing attention has been given to the protection and recovery of rare, threatened and endangered species, especially on the public lands.

But what of the private lands? Are they becoming sterile? What contribution are the landowners making to the conservation of our natural resources? Surprisingly, little is known. One of the major research problems is the very fact that private lands are private.

Many private landowners eschew publicity and visitors. Some are unwilling or unable to tolerate or manage public visitation and use of their lands. Just as homeowners are concerned about their lawns or landscapings, the owners of farms, ranches, and forestlands worry about trespassers, damage to their crops, lands, trees, domestic animals and property. Many corporate and industrial landowners require considerable security in running their operations. Others derive income from charging for the privilege to use and enjoy the resource; still others

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have restricted memberships, and some are accessible only to an exclusive clientele. Nearly all private landowners are worried about the threat of litigation from visitors, invited or uninvited, who might come to some harm on their lands. As litigation has become increasingly prevalent in our society, this fear has become a growing, major, and justified concern. It is often easier for private landowners who are not dependent upon public uses of their lands to simply adopt a policy of excluding the public. This eliminates problems, prevents damage, and avoids lawsuits.

Yet this very exclusivity also offers the opportunity to safeguard natural and biotic resources on these lands. It reduces one of the major growing problems in our affluent and ever more recreation-oriented society: overuse of the land and its resources. We may be in some danger of loving the land to death. Visitors who crowd into more popular national parks, seashores, recreational areas and wildlife refuges can be, and increasingly are, detrimental to the preservation of the very environmental amenities these areas were created to protect and preserve.

In an earlier day, government land managers devoted much of their time to the protection of game species from overhunting; now they increasingly have to protect lands and wildlife from over-camping, over-littering, over-trampling, over-disturbing, and even over-watching. In some parts of the country, the ever-growing throngs of recreational birdwatchers have posed a threat to the survival of rare or endangered species. In their zealous pursuit of adding as many species as possible, especially the rare and vanishing species, to their "life lists," birders can occasionally threaten the breeding success of small and fragile populations. In central Michigan, for instance, in the limited range of the endangered Kirtland's warbler, visitor use has become such a problem that the U.S. Fish and Wildlife Service now allows entry to the area only by officially scheduled and guided field trips.

Yet attempts to close or severely restrict public access to the public lands is hardly popular, and often misunderstood. Recreationists may feel that as taxpayers they can rightly demand access to "their" lands. Attempts to close public lands to off-road-vehicles, hunting, grazing, etc., can generate vigorous protests and letter-writing campaigns that sometimes lead to management decisions that conflict with the successful long-term protection of the resource.

This problem can sometimes be more easily resolved within the secure and exclusive private property of the private sector landowner. Some especially important and productive private wildlife sanctuaries are either closed to public visitation and use or are carefully controlled and monitored at specific times of the season or year to minimize disturbance or harm to the resources. For instance, the National Audubon Society's 26,800–acre Paul J. Rainey Wildlife Sanctuary in coastal Louisiana is closed to public visitors in order to prevent disturbance of the wildlife, and also to minimize management costs. The small population of endangered American crocodiles sequestered within the securely fenced and patrolled confines of Florida Power & Light Co.'s Turkey Point plant, south of Miami, are free from threats of disturbance or poaching. Likewise, the thriving colony of least terns nesting on crushed seashells within Exxon's Grand Isle Gas Plant in the waters off coastal Louisiana, is free from disturbance by fishermen, recreationists and sunbathers who have often disturbed colonies on beaches with ready public access.

Because private property rights in the United States are relatively secure and extensive, private owners have the ability to protect their lands from over use. And as demand increases, it is relatively easy to prevent overcrowding through the rationing mechanism of the price system. Higher entrance fees or user fees will reduce crowding and queuing. Such revenues also provide funds and an incentive for increasing an owner's investments in protection of the resource.

Inventory of Private Sector Natural Resource Conservation Activities

The government's efforts in natural resource conservation are usually well known, well publicized, and well documented. Relatively little is known about what is on the private lands or how well it is being protected. Nor do we know how to encourage the private sector to undertake a greater role in the protection of our natural heritage.

Thus, it is easy to see how some people have come to accept the idea that if natural resource protection is not guaranteed by Washington, D.C., it is probably not being done. The efforts of government wildlife managers and biologists to save endangered whooping cranes and Kirtland's warblers are generally well-known. What we don't read about very often are the quiet efforts of private landowners: a small farmer in Wisconsin who provides habitat for wildlife on his farm; a rancher in Texas who protects rare game mammals; a forest products company that helps hard-pressed, hole-nesting birds by providing nest boxes at cost to landowners; a garden club that preserves rare and endangered flowers; a small land trust in the Great Plains that protects remnant prairie grass preserves.

The rest of this chapter documents some of the outstanding examples of these private sector programs. It is part of a larger attempt by the Council to develop a representative inventory of private-sector natural resource conservation activities throughout the United States. This universe of activities and programs is grouped into a workable number of major functional categories. Within this broad range of categories, encompassing everything from small nature clubs and land trusts protecting only a few acres, to giant corporations owning hundreds of thousands and sometimes millions of acres of lands, case studies of especially innovative programs have been selected for publication in this report.

Major Wildlife and Conservation Organizations

These nonprofit, tax-exempt organizations include the first state, regional and national groups formed to protect and preserve the many species of wildlife that were rapidly disappearing at the turn of the century. They purchased and protected habitat and breeding areas, patrolled some of them with private wardens, and sought enactment of legislation to protect native wildlife species. As ecological and environmental knowledge expanded, new organizations were formed to acquire and preserve representative examples of unique natural diversity and habitat throughout the nation. These various organizations own and preserve a minimum of a million acres of refuges.

By comparison, the U.S. Fish and Wildlife Service owns 9.5 million acres,

outside of Alaska mostly in refuges. The major organizations have often worked cooperatively with the federal, state and local governments to acquire important natural resource areas threatened with development, frequently transferring them to public ownership when legislation and funding made it possible. They have also leased areas from the government that have a particular importance to their concerns and missions and provided intensive management and care to these resources. However, there appears to be an increasing trend for these groups to maintain the areas they acquire in exclusive, private ownership in order to avoid many of the difficult problems arising from public ownership—multiple use, growing recreation demands, and political considerations. The largest and best known of the private, nonprofit organizations is The Nature Conservancy, which owns and manages a national system of nearly 800 sanctuaries (and has preserved some 2.4 million acres since 1951); the National Audubon Society (NAS), which has a sanctuary system of over 63 units totalling over 250,000 acres.

CASE STUDY: MICHIGAN AUDUBON SOCIETY

The Michigan Audubon Society (MAS) celebrated its 80th anniversary in 1984. It was organized and incorporated in 1904 "for the purpose of promoting among the people of Michigan an interest in our native birds for their great economic, cultural, and recreational value; to promote conservation of wildlife and the natural beauty of Michigan in all practical ways; and to cooperate with other organizations working for the true conservation of all natural resources." It is the oldest conservation organization in the State of Michigan and one of the oldest Audubon societies in the nation. MAS became a state chapter of the National Audubon Society in March 1972. Forty-two Michigan Society Chapters serve the Audubon cause in their respective communities.

MAS is a nonprofit corporation and contributions are tax-deductible. It is supported by membership dues and contributions. An Endowment Fund was started in the 1940s and the annual interest goes to the operation and programs of the Society. The Endowment is funded through life memberships, gifts and contributions, and the sale of items contributed to the Craft Shop and birdseed sales.

Annual dues are $30 for an individual and $38 for a family, which is a joint membership in the MAS and the National Audubon Society, and the members receive *Audubon* magazine as well as the two publications of MAS, *The Jack-Pine Warbler* and *The Michigan Audubon News*. There are reduced rates for senior citizens and students. The dues are split between MAS and the NAS. The NAS provides assistance and services to the MAS, including help with membership drives. A Life Membership in MAS, which is $200, is not shared with National and goes directly to the Endowment Fund which is nearly a half million dollars. The current annual operating budget is about $120,000, not counting restricted funds. Michigan Audubon has about 6,500 memberships, totalling 15,000 members. The membership of 42 affiliated chapters is about 4,000, making MAS the second largest National Audubon chapter in the country.

MAS has operated over the years largely as a volunteer organization, with

a relatively small paid staff of two full-time employees and three part-time employees. For most of its history, its headquarters was wherever its officers lived or worked. However, it now has a business office and an administrative assistant, an extensive library, and maintains one of the largest natural history bookstores in the state. Because of its growing membership and activities throughout Michigan, MAS plans to obtain a full-time executive director in the near future.

Originally started as an organization devoted to the enjoyment and protection of birds when Michigan was predominantly a rural and agricultural state, MAS has increasingly seen its role and mission evolve as more and more people live in urban centers and have less daily contact with nature. The Society believes that the modern environment of "plastic, glass, cement, steel and aluminum makes it difficult to establish rapport with perishable wild flowers, insects, frogs, and birds, or to see important relationships among living creatures and rocks, soil, air and water, much less to comprehend modern man's dependence upon such things for his very existence." Thus, it has undertaken and developed a major educational program designed to meet the needs of the members of a modern society. These include efforts "to develop in the people of Michigan a better understanding and appreciation of our natural surroundings and of the problems we face in the management of natural resources; to provide opportunities for constructive outdoor living through organized programs of study and group activities; and to provide a statewide program of leadership training in the field of nature study and conservation."

Educational Programs

The MAS educational programs include Junior Audubon Camps and Day Camps during the summer, lectures, film series, and programs and courses for grade school through college, including adult education. A Nature Counselors Training Camp is offered for groups such as the YM-YWCA, Boy and Girl Scouts, CYO, and private camps. The two MAS nature centers are actively involved in the education program as they are combination wildlife sanctuaries and outdoor environmental centers. They offer tours for school groups, nature classes, environmental education to the community, a high school naturalist training program, and nature education workshops for teachers. In addition, the centers, in cooperation with Michigan State University, offer courses in environmental teaching and conservation education, and 10-week sessions throughout the year for MSU student-interns who are seniors in biological and ecological studies.

The first nature center to open was the 243-acre Seven Ponds Nature Center in Lapeer County. It was licensed to the Society in 1966 and contains bog-lakes, uplands, fields, woods, and a building for educational activities. The Seven Ponds Center has a director and is partially financed through a separate endowment fund.

The 350-acre Lew Sarett Nature Center in Berrien County was presented to MAS in 1964. It is located in the midst of an expanding urban development area where it preserves a wide variety of biotic resources. The site is on bluffs and bottomlands along the banks of the Paw Paw River and contains upland meadow and forest, floodplain forest, shrub carr (old marsh interspersed with pioneering trees), bog, sedge meadow, and cattail marsh habitats. Improvements

to the area have included the planting of native trees and wildlife food plots and the development of an extensive trail system, including boardwalks and woodchip-covered trails. Several wildlife ponds have been constructed, including one with an island.

As community education is conducted at Sarett, including accredited course work for teachers and MSU students, it has a major environmental interpretive building, a nature lab, and a dormitory for students. The Center also maintains a native tree and shrub arboretum.

Sarett staff includes a director and chief naturalist year-round, and during the winter when educational and recreational programs are expanded, nine naturalist-ski instructors direct a cross-country skiing program. Because of these extensive and costly programs, Sarett is partly funded through its own separate membership program and endowment fund. Both centers charge fees for non-members; each receives about 20,000 visitors annually, mostly students and teachers attending the various educational programs and courses.

Educational programs for MAS members also include seasonal campouts in important natural areas of the state and regular outings to Isle Royal. Field trips are scheduled throughout the year within Michigan and tours are offered to other environmentally significant areas within the U.S. as well as in many foreign countries.

A feature of MAS' annual convention is an annual awards program recognizing individuals, corporations and governmental agencies for outstanding contributions to environmental preservation and wildlife conservation. Corporations are honored for non-monetary contributions to environmental protection.

Nature Activities

MAS' wide range of nature activities includes a major emphasis on censuses of Michigan birdlife: the Christmas Bird Count, the Spring Bird Count, and a statewide winter bird feeder count. MAS cooperates in many wildlife research efforts with the Michigan Department of Natural Resources, including the ambitious task of preparing a Michigan Breeding Bird Atlas covering the entire state in great detail, expected to be completed in 1988. This will establish statewide baseline data for breeding bird populations, help determine trends, and help identify and assist threatened and endangered species.

Many of the chapters are also active in a Recovery Program. Part of this involves the creation and maintenance of bluebird nest box trails, to counter the severe decline in the eastern bluebird population of the western Great Lakes region. It also includes guided tours, given by the U.S. Fish and Wildlife Service (USFWS), of the Kirtland's warbler nesting grounds in central Michigan. This extremely endangered species, whose population has been decreasing alarmingly until recently, nests only in Michigan in stands of young jack pine trees. One concern in the Recovery Program was disturbance of the nesting birds by over-zealous birdwatchers, and recently the USFWS banned unguided access into the limited nesting area. MAS volunteers assisted in replanting young jack pine trees (some 1.2 million seedlings were planted in 1983) throughout the area as well as in the prescribed burns required to maintain optimal habitat.

Sanctuaries and Refuges

The Michigan Audubon Society also maintains a relatively small but significant system of 10 wildlife sanctuaries and refuges throughout the state, totalling about 2,500 acres. Seven are essentially undeveloped wildlife and habitat refuges, two have also become important nature centers offering extensive educational and training programs with staffs of directors and naturalists, and one is a bird observatory. Most of the land was donated to the Society by individuals or trusts, some was purchased by members, and a small amount was purchased directly by MAS. These lands are owned in fee by MAS, with the exception of the Whitefish Point Bird Observatory, which is leased from the U.S. Coast Guard. MAS has not been heavily involved in the use of conservation easements, employing this preservation technique only at the Haehnle Sanctuary.

Rather than building an extensive refuge system, MAS' primary emphasis has been on providing sound stewardship for its existing sanctuaries and nature centers. It recently obtained small areas adjacent to some sanctuaries to help protect and buffer them; a few have independent membership programs to help fund their management; several are jointly managed by MAS chapters. Most of the major sanctuaries protect important wetland areas. The purpose of the sanctuary system is to preserve the habitat and wildlife for future generations.

Bernard N. Baker Sanctuary

The most important and significant refuge is the Bernard W. Baker Sanctuary located in Calhoun County in southern Michigan. The first sanctuary in the system, established in 1941, it is also the largest (897.5 acres). It is predominantly wetlands and swamps and is an important nesting and staging area for the sandhill crane. In the 1930s, naturalists had grown concerned about the declining crane population and the increased drainage of its marshland habitat throughout the state. Particularly notable were the efforts of Dr. Lawrence H. Walkinshaw, a dentist and amateur ornithologist, who began field studies of the cranes in the 1920s and who was largely responsible for getting the Baker Sanctuary created. The original gift of 491 acres was probably the nation's first sandhill crane sanctuary.

About 75 percent of the Baker area is water-covered at some time of the year, and marsh grasses and sedges predominate. The Big Marsh Lake and swamp occupy about 200 acres and are surrounded by swampy hardwoods. There is also an important bog with a 40-acre stand of tamarack and some orchid species. There is a large floodplain forest, a large cattail marsh, and a mesic prairie. There are two major trails on the refuge. One is a self-interpretive native wild flower trail that winds through many different habitats that is maintained through an independent charitable foundation endowment. Baker has a resident caretaker, and a lodge on the property that can be used for environmental studies. Future plans call for the construction of a nature center, a museum, and several ponds. The Michigan Department of Natural Resources has also suggested that osprey nesting platforms be erected on the refuge.

The area has been well preserved and the habitat is very similar to what it was at the turn of the century. Some 500–600 cranes now gather during the

fall migration at Baker. Through this and similar efforts to protect and preserve the habitat for sandhill cranes — including wetlands owned or leased by the private, nonprofit Michigan Nature Association, as well as the Michigan Department of Natural Resources and the U.S. Fish and Wildlife Service — the birds have slowly been recovering over the past 45 years.

Baker Sanctuary Oil and Gas Lease

Perhaps the most innovative aspect of the management of the Baker Sanctuary was initiated in January 1981 when the MAS and the Michigan Petroleum Exploration, Inc., drew up an agreement and a "no trespass" oil and gas lease for a small portion of the sanctuary, "for the exploration and production of hydrocarbons in a manner which will preserve the ecology and safeguard the environment of this sanctuary."

The detailed eight-page lease contained stringent safeguards to protect the refuge and to insure strict compliance with the "no trespass" provisions. The lease was to continue for as long as the hydrocarbons could be produced in paying quantities. The primary concern of MAS was to protect the environment for the sandhill cranes, so the "no trespass" lease prohibited operations and activities on the surface of the leased property. The drill site was located off the sanctuary property, using off-site or directional drilling. Drilling was permitted only between 18 December and 10 March to avoid disturbing the cranes, and no seismic or geophysical testing was permitted. To minimize the possibility of any spills, only one hole was permitted to be a producing well, all circulation of drilling fluids was to utilize tanks, plastic-lined pits, etc., so that no drilling fluids would come into contact with the surface of the earth. To prevent the possiblity of subsurface water contamination, an inground casing system had to be cemented from the surface into the bedrock. Further protection was mandated through the installation of high-efficiency mufflers on drilling equipment and electric motors to minimize noise; the company agreed to minimize any odors, and all production equipment was painted medium moss green to blend with natural surroundings. All waste material had to be disposed of properly and the company agreed to pay in the event of any inadvertent damages.

Michigan Petroleum Exploration agreed to pay MAS a royalty of 18.75 percent of the proceeds at the prevailing market price from the sale of any hydrocarbons. The Company also paid all attorney's fees and reasonable expenses in drafting the lease. In addition, it paid for a monitor appointed by MAS to oversee operations and insure environmental protection, as well as for a more extensive research and monitoring program. MAS will repay these initial expenses from future royalites.

A producing well was brought in and the Michigan Audubon Society received about $100,000 in royalty payments in the first year. Production is now dwindling and royalty payments are down to about $50,000. However, these sizeable royalties helped the Endowment Fund grow considerably, so that MAS is better prepared to continue its mission. Thirty percent of the interest from the mineral royalty endowment goes for maintenance and improvement of other MAS sanctuaries.

Given the conventional polarization between pro-development and pro-preservationist philosophies that has developed during the environmental decade

of the 1970s, this was an important and innovative development, especially since the National Audubon Society has argued that economic development was incompatible with the preservation and protection of federally-owned wildlife refuges. The results have shown that with careful stewardship and clearly defined property rights and obligations, petroleum production and wildlife can coexist.

MAS initiated an environmental study of the Baker Sanctuary "to assess the efforts of the hydrocarbon development on avian populations." The initial report concluded:

> "These data do not suggest any impact of hydrocarbon development on avian populations that is overriding the pattern of vegetation and natural population variations typical of the sanctuary. Furthermore, the birds breeding in the sanctuary in habitats adjacent to the well site were not noticeably disturbed by the presence of humans or the noise of the well-drilling. Also contributing to the apparent lack of effect was the location of the well off the sanctuary and the winter-early spring drilling activities which were completed before the majority of breeding species had arrived."

Recently, another oil company has approached MAS about obtaining a "no trespass" lease to explore another area of the Baker Sanctuary. The Society has also recently become a member of the Kalamazoo County Chamber of Commerce.

Other Sanctuaries and Refuges

Another major wildlife refuge is the Phyllis Haehnle Memorial Sanctuary, 705 acres of predominantly marshland along the Portage River in Jackson County. It contains Mud Lake Marsh, Bogus Lake, and the edge of Eagle Lake. It is a major haven for sandhill cranes, with a total of 1,800 counted in recent autumns. Black terns nest on the refuge and it contains a threatened orchid species. It is under the joint stewardship of the Jackson Audubon Society and the MAS.

The Whitefish Point Bird Observatory is an independent nonprofit organization sponsored by MAS and a number of other groups, and receives some funding from the USFWS for its ornithological studies. It is partly maintained through its separate membership dues program. Located on the Upper Peninsula on the shore of Lake Superior, it is a major spring migration bird concentration area with counting and banding of raptors being its major scientific contribution. The notable spring flight includes 15,000–25,000 raptors and 5,000–7,000 loons. It is staffed by a paid seasonal director and four assistants.

All MAS sanctuaries are open to the public; however, they do have restrictions controlling their use. Some 50,000 people visit the sanctuary system each year. The Whitefish Point Bird Observatory receives a few thousand visitors. The number of visitors to the various refuges is unknown as they have no staffs and visitation ranges from individuals to busloads of birders.

Publications

The Society also has an active publication program which includes calendars, nature notes, guides to attracting and feeding birds, bird-finding guides and checklists. MAS publishes a quarterly magazine, *The Jack-Pine Warbler*,

which was started in 1932, and carries articles of scientific research dealing with ornithology and natural history. Funding for the magazine is achieved partly through a special endowment from the sale of used books contributed by MAS members. A bimonthly newsletter, *The Michigan Audubon News*, was started in 1952 and contains news of general interest to conservationists and environmentalists, reports on the activities and programs of MAS and its chapters, and covers important environmental legislation and problems within the state and nation.

MAS and its chapters have played a major role within the state to promote the protection of Michigan's wetlands, to create a Michigan nongame tax checkoff program administered by the Michigan Department of Natural Resources, and to monitor the U.S. Army Corps of Engineers permit applications.

The Michigan Audubon Society had much to celebrate upon its 80th anniversary in 1984, and its achievements over the years indicate what can be accomplished with a small staff, a limited budget, a strong sense of mission, an enthusiastic network of dedicated volunteers, and reliance upon private initiative. [Michigan Audubon Society, 409 West E Avenue, Kalamazoo, MI 49007]

Land Trusts, Watershed Associations

These nonprofit, tax-exempt organizations include some of the earliest private attempts to preserve and protect natural resources, open space, and scenic, historical and archaeological sites. Most are local efforts; some are statewide. The majority have annual budgets of less than $5,000; a few have budgets in excess of $1,000,000. Most have very small full-time and part-time staffs and rely extensively upon local, volunteer help. In total, there are between 400 and 500 organizations preserving about 700,000 acres. These trusts and societies have played a disproportionately significant role within their regions by their early identification and actions to preserve important examples of vanishing natural resource amenities. About 200 of them are located in New England where population growth, and economic and agricultural development first had a negative impact on natural areas, scenic and historic sites. At least 80 are located in Connecticut, the fourth most densely populated state.

CASE STUDY: THE TRUSTEES OF RESERVATIONS

This nonprofit, charitable corporation was founded in 1891 for conservation purposes to protect the countryside of Massachusetts, especially to preserve for the public its "beautiful and historical places and tracts of land." At present The Trustees of Reservations (TTOR) have acquired and are custodians for 68 properties from western Berkshire County to Cape Cod, Martha's Vineyard and Nantucket, totalling some 16,215 acres. These lands have been acquired in fee through gift, bequest, and purchase with funds raised for acquisition. An additional 55 areas and 5,071 acres are protected through conservation easements and restrictions. Another 50,000 acres are indirectly protected.

This was the first independent organization in the United States established for the purpose of land preservation. Its purpose was to preserve in perpetuity areas with unique natural importance, scenic beauty, and historic value. TTOR

served as the model for the creation of similar trusts elsewhere, beginning in 1894 with The National Trust for Places of Historic Interest or Natural Beauty in England, which adopted its articles of establishment directly after TTOR's. The National Trust for Scotland in 1935 and the U.S. National Trust for Historic Preservation in 1949 were also patterned after the TTOR. Commenting on the 90th anniversary of its founding in 1981, the English magazine *Country Life* noted in an editorial that TTOR was "the effective inaugurator of the Trust movement" throughout the world.

Much of the credit for developing the idea of "promoting conservation through voluntary agencies" must be given to Charles Eliot. In February 1890, long before the current concern for environmental preservation, Eliot, son of the then president of Harvard College, wrote to *Garden and Forest* magazine, urging the protection of the countryside throughout Massachusetts. He expressed concern that "several bits of scenery which possess uncommon beauty and unusual refreshing power are in daily danger of destruction." He further urged the establishment of "an incorporated association composed of citizens of [Massachusetts] and empowered by the state to hold small and well-distributed parcels of land free of taxes, just as the Public Library holds books and the Art Museum pictures for the use and enjoyment of the public."

In 1891, The Trustees of Reservations was founded by Act of the Massachusetts General Court to hold and maintain for the public, under suitable rules and regulations, "beautiful and historical places and tracts of land within this Commonwealth."

Membership Organization

The Trustees of Reservations is a membership organization and is funded through membership subscriptions as well as gifts of money and land by individuals, corporations and foundations. Contributions are deductible under federal income tax law. Membership categories range from individual at $20 to sponsor at $500, and there is a special category for subscriptions of $1,000 or above, The 1891 Society. Members receive decals and cards, free admission at historic house museums and many other properties, and discounts on tickets to two of their most popular properties, Richard T. Crane, Jr. Memorial Reservation (Crane Beach) and Rocky Woods. Members also receive the illustrated *A Guide to Properties of The Trustees of Reservations*, a quarterly Newsletter, the Annual Report, and invitations to field days, outings, special events, and lectures. Members of The 1891 Society are invited to two special outings each year.

In 1983, the operating budget of The Trustees of Reservations topped two million dollars for the first time in its history. It consisted of total income of $2,058,153 (a 14 percent increase over 1982) with total expenses of $2,108,975 (a 13 percent increase over 1982). The basic operations of the organization are funded by memberships, annual gifts, admissions fees and the income from various endowment funds and trusts. Memberships and contributions have risen significantly in recent years as a result of diligent efforts to broaden the membership base and to conduct successful fund-raising efforts.

TTOR has two types of memberships, general and Friends. In 1983, total membership reached 3,811, contributing $182,004 in dues—representing a 22

percent membership increase and a 13 percent dues increase over 1982. Of that total, 990 members ($39,240) were general memberships, with the dues helping to balance TTOR's annual operating budget; 2,281 members ($142,764) were Friends memberships, whose dues are used exclusively for the annual operating support of individual TTOR properties affiliated with each of nine geographic Friends groups.

Additionally, there is the Annual Appeal which provides vital support for operating expenses. In 1983, it raised $291,049 (24 percent more than in 1982) from 1,324 donors (a 26 percent increase over 1982). General contributions of $198,049 came from 917 donors—a number of which were not members, and designated contributions from 407 contributors raised another $93,000. All told, total gift income in 1983 was $473,053 from 5,135 donors and members.

The Trustees of Reservations is a very decentralized and highly volunteer-dependent organization. The governing board of the organization consists of a 14-member Standing Committee which meets monthly with an Advisory Council. The officers of TTOR and the members of the Standing Committee are elected annually by the 150 Trustees or "members of the corporation." There are also a number of special subcommittees under the Standing Committee.

The full-time staff is quite small, only slightly more than 40 employees. During the busy summer season, part-time employees bring the staff to over 170.

There are also five Regional Committees dealing with management and budget issues for the properties within their regions. Voluntarism is most prevalent at the local level. Nearly all of the 68 reservations have a Local Committee, consisting mainly of area residents, whose special knowledge of and concern for the properties is tapped for advice and volunteer assistance in management of the reservations. Volunteers make up the bulk of all the committees, from the Standing Committee to the smallest Local Committee.

The various management regions have a great deal of autonomy in developing the long-range ecological and management plans for the various reservations. They rely on the professional field staff, volunteers and, occasionally, consultants. Management Regions also have paid Superintendents.

A Museum of the Massachusetts Landscape

With its 68 acquired properties or reservations and 55 conservation easement/restriction areas protecting over 21,000 acres throughout the state, The Trustees is virtually "A Museum of the Massachusetts Landscape."

Its properties include everything from wildlands, natural sites, and open space, to historic homes and formal gardens. The lands they have acquired include both natural areas and landscaped areas, preserving ecology as well as scenic beauty and historic sites. The many historic homes are used as museums. They also protect significant areas of the state's geology, archaeology, landforms, botany, and ornithology as out-of-doors museums.

The reservations include examples of scenic and natural sites including "brooks, rivers and waterfalls, glens and chasms, forests and swamp lands," and wildlands such as "ocean beaches and sand dunes, ferns and wildflower communities, bogs, mountain tops, shorebird rookeries, deer runs, deep woodlands where bear roam, and ponds still inhabited by beaver, muskrat and otter." Examples of an earlier countryside are preserved as "rolling fields and forests,

pastures and stone fences, colonial farmhouses and barns." Outstanding examples of formal landscapes include "great houses and their gardens, sweeping lawns and statuary, terraces and courtyards, stately shade trees, shrubs and flowers."

Preservation Mission

Preservation in perpetuity is the primary purpose of The Trustees and this sets them apart from public agencies which are primarily interested in providing recreational opportunities. For the TTOR, preservation takes precedence over recreation, whenever conflicts between enjoyment and preservation arise, since preservation of the scenic and ecological values of its properties is its goal.

This goal is spelled out in TTOR's management policy:

> "Preservation is our primary purpose, and thus we necessarily encourage visitation of a lower intensity than most of the public resource agencies which are engaged as well in providing opportunities for recreation. We may also appropriately discourage use of properties where such use is of an intensity which may jeopardize basic scenic and ecological values as well as the quality of the experience of the individual visitor.
>
> "In individual cases the interpretation and administration of this policy must be left to management decisions which reflect specific local conditions. Hence the actual operation may vary from time to time, as ecologic conditions and/or patterns of use vary. Under normal conditions we will leave the operating decisions to Regional Supervisors and Reservation Local Committees. Where such decisions are seriously questioned, appeal may be made to the Committee on Management and Protection and, ultimately, to the Standing Committee.
>
> "In all cases, the decisions will inevitably be 'judgment' decisions in which preservation and conservation are recognized as the dominant criteria with the maintenance of the tranquility of the area and its passive enjoyment by the general public as *secondary*. Thus, a particularly sensitive area may be closed entirely to public access, for a time; or an area may be open to a limited number of persons at any one time."

This policy illustrates one of the major strengths of private sector ownership: flexibility, adaptability, and the ability to make immediate policy changes at the local level. Most of the reservations have long-term master plans, especially the larger ones, or else they are being prepared. Currently, Doane's Falls, a 30-acre property near Royalston in central Massachusetts, which preserves a spectacular series of waterfalls and deep pools where "Lawrence Brook flows through a granite gorge crowned with pine and hemlock on its way to Tully River" is suffering from overuse. "Growing intensity of public use is compacting trails, increasing the accumulation of litter and jeopardizing the tranquility of the area." The Local Committee is now considering various management alternatives.

Public Education

Nevertheless, The Trustees recognizes that use and preservation are not necessarily contradictory, and realizes the value of educating the public and receiving

support that comes through wise use of its properties. Part of its mission is education, and the various properties are managed as education museums for the public. There are interpretive programs for visitors associated with most of the properties, which include guides, lectures, booklets, folders and leaflets, panel displays, interpretive trails, etc. Many properties have hostesses, guides, wardens, and naturalists. Some have visitor centers.

Furthermore, revenues from admissions fees, user fees, the sale of booklets, and special events make a major contribution to the annual operating budget, and the upkeep and maintenance of the reservations. In recent years, reservation receipts and sales have averaged 35 percent of annual operating income.

The Trustees of Reservations acquires, protects, and manages areas for a number of reasons. These include the following categories: agricultural and forest lands, historic and archeological sites, rights-of-way, scenic and recreational areas, wildlife habitat, and wetlands and coastal areas.

Two units typify the scope of the organization's interests. *Bear's Den*, a 3.4 acre area in North New Salem, consists of a tiny grotto with a sparkling waterfall on the Middle Branch of the Swift River, where legend says King Philip gathered with his Indian chieftains in 1675 to plan the march and massacre of settlers in Deerfield. This was acquired as a bequest of Mrs. Grais Burrage in 1968. *Crane Beach* is 1,352 acres of dunes, woodlands, and marshes and four miles of ocean frontage in Ipswich, about a 90–minute drive from Boston. This is the most heavily used natural area owned and run by any private, nonprofit group in the United States. It receives over 500,000 visits per year. Its staff reaches 60 during the summer peak-use period. The admission price is $6.50 per car. There is now a year-round user fee. Previously, there had been none in the winter, but uncontrolled access caused problems. The revenues are used both to oversee the visitors as well as to care for the area and conduct scientific and educational activities, including the protection and management of the area's colony of nesting least and common terns.

The organization also maintains a broad outreach program involving education and proselytizing. It provides counselling in land preservation techniques to private landowners, conservation commissions, planning boards, local land and conservation trusts, community organizations, and citizens. In addition to these general programs promoting the wise use of open land and the preservation of natural areas, it has several quite specific programs. These include a forest demonstration project showing private forest landowners how to improve the scenic values of their land and protect wildlife and habitat, while producing income from the sale of selective timber resources.

As The Trustees of Reservations enters its 94th year, it stands out as a model of far-sighted thinking regarding the need to set aside representative examples of the natural and historic landscape for the perpetual enjoyment and education of the people. The innovative approach of using a voluntary, nonprofit organization to hold, in trust, assets for the use of the public, helped to create an adaptive and flexible method of preserving areas which governmental entities did not have the mandate or finances to protect. TTOR has helped spawn a variety of private land trusts, and has worked cooperatively with government at all levels to encourage the creation of programs to protect natural landscapes throughout the country. [The Trustees of Reservations, 224 Adams Street, Milton, MA 02186]

CASE STUDY: THE ARCHAEOLOGICAL CONSERVANCY

The Archaeological Conservancy (TAC) was founded in 1979 as a nonprofit membership organization for the purpose of "the permanent preservation of the most significant prehistoric sites in the United States." TAC cooperates with government, universities, museums, private conservation organizations, corporations and private landowners to acquire lands for their permanent preservation as archaeological preserves. They have an Eastern Regional Office in New York City and they publish *The Archaeological Conservancy Newsletter.* Stewart L. Udall is the Chairman of the Board.

TAC has a current membership of 3,000, consisting mostly of individuals, plus a few organizations. Membership dues run on a sliding scale beginning at $25.00.

TAC works mainly through state historic preservation groups and local archaeologists to identify important sites for protection or acquisition, usually in fee simple, although it will also accept archaeological easements.

TAC own 27 archaeological preserves in 11 states. The sites are generally very small and thus acreage is not significant, totalling 800–900 acres. Some preserves are less than one acre; some cover several hundred acres. TAC believes the best protection method is fee simple acquisition. If that is not possible, it will use easements, as was done to protect a series of sites all located on one property in California. It is also working with easements in other states.

Due to the nature of the resource and the difficulty of protecting archaeological sites, all of their preserves are closed to the general public, but open to professional archaeologists. TAC does not itself excavate sites, but accepts project proposals from reputable archaeological teams to work a site. These are carefully evaluated before being approved because preservation of the site and its associated informational value is of primary concern.

Conservation Archaeology

The Archaeological Conservancy is a firm believer in "conservation archaeology." The philosophy and practices of archaeology are changing rapidly. Formerly, it was "treasure" oriented. Early techniques were to dig up the site and put the relics in a museum or on display. Today it takes much longer to work a site. The emphasis now is to learn as much as possible about how the inhabitants lived. Modern archaeologists examine seeds, pollen, bones, ashes, wood fragments, stone and shell beads, etc., in order to determine what the past climate was, what crops were used, what animals were hunted or domesticated, what trade routes were followed, and what the nature of the culture and society was. TAC believes that in a hundred years, archaeologists will be able to learn still far more from a site than they can today with present techniques, technologies, and philosophies. Thus, the permanent preservation of a site is more important than working it now. TAC believes the best thing one can do to an archaeological site is to leave it alone.

While a few archaeological sites are owned by universities or museums, and many are protected on public lands, a significant number are on private land. This is not only true in the East but also in the West, where vast amounts of the land are owned by the federal government. Because of the importance of

water in the arid West, the Anasazi often settled along river valleys, in riparian areas, or near springs. However, these are also the areas that were usually homesteaded by settlers and are now cattle ranches, farms, homesteads, etc. Thus, although many western states have a large percentage of land in government ownership, a disproportionate number of archaeological sites are located on private lands.

A majority of the sites on private land are unprotected, except to the extent that they are protected from trespass and disturbance as private property, and there is seldom legislation to prevent these sites from being looted. The Archaeological Conservancy was created to monitor hundreds of such sites around the country and can often step in quickly to acquire them if they are threatened by development or looting.

Part of TAC's mission is also educational: it actively proselytizes. TAC members will meet with large corporations or ranchers who are unaware that they own land that contains an important archaeological site. If petroleum or mining exploration or development threatens a site, they will provide advice on how to minimize disturbance to the site, and might suggest the selection of alternate drilling locations.

Tax Treatment of Sites

A very important issue for The Archaeological Conservancy is the tax treatment of archaeological site preservation and easements. Most of its preserves are donated to TAC, and the value of the contribution is an important concern of the donor. Is the value based on historic value or on the value of the artifacts in the ground? Is it based on current land use practices such as ranching or timber production or on alternative uses such as housing subdevelopments? Generally, the donor receives a federal income tax deduction equal to the base value of the land. The IRS usually resolves these disputes through private letter rulings which do not set a precedent. TAC believes it would help its mission immensely to resolve such issues through the creation of standardized evaluation procedures, as it would likely then receive more site donations.

TAC notes that while the easement evaluation issue is critical for much of the land trust movement, it has not been a pressing issue for TAC which makes limited use of archaeological easements. Those it does have on rural land have little value.

TAC has increasingly been working with developers in an attempt to try to save sites by having the developer create an open site or open space within the subdevelopment, which would then be given to TAC. The landowner or developer receives a tax deduction, may well increase the value of the development through including open space, and gains favorable publicity for the conservation effort. [The Archaeological Conservancy, 415 Orchard Drive, Santa Fe, NM 87501]

Large Corporate Industrial and Private Landowners

This category includes tens of millions of acres of lands owned by major private, and often well-known businesses throughout the country. The sheer

size and extent of the lands owned by many of these companies and individuals places them perforce in the wildlife, habitat, and recreation management business. The lands are vast reservoirs of natural diversity, wildlife habitat and wildlife species, and also provide numerous opportunities for outdoor recreation. Increasingly, the owners are recognizing the profit potentials in managing these lands for the provision of public amenities for fee access, as well as the public relations and corporate goodwill aspects of demonstrating their concern and sound stewardship of the environment.

CASE STUDY: NORTH MAINE WOODS, INC.

North Maine Woods (NMW) is one of the most complex and innovative programs of multiple use of private lands for commercial timber production and public recreation in the country. This is a vast multi-ownership region of undeveloped, primitive forestland covering some 2,783,170 acres (about 4,349 square miles) in the northwest corner of Maine, abutting Quebec and New Brunswick, and extending 90 miles from North to South and 72 miles from East to West at its widest points. It includes two of the most noted wild rivers in New England, the Upper St. John and the Allagash, both of which have numerous whitewater stretches. The 92-mile long Allagash Wilderness Waterway is completely surrounded by the NMW. The area contains a great many smaller rivers and streams, numerous lakes, ponds and bogs. Some 170 lakes and ponds have been surveyed and mapped by the Maine Department of Inland Fisheries and Wildlife. The rolling, uneven glaciated terrain consists of many hills and mountains, some over 2,000 feet in elevation, interspersed with narrow valleys. The region is heavily forested and abounds with fish and wildlife.

This is predominantly an area of northern coniferous or boreal forest associations dominated by spruce and fir, but containing many other species, including hardwoods. There are also many species of wildflowers. The resident mammals include snowshoe hare, red squirrel, beaver, muskrat, porcupine, (Eastern) coyote, black bear, racoon, weasel, mink, river otter, marten, fisher, bobcat, lynx, moose, and white-tailed deer. Among the avifauna, including a variety of species at or near the southern edge of their breeding ranges, are common loon, common goldeneye, golden eagle, bald eagle, northern goshawk, spruce grouse, three-toed woodpecker, black-backed woodpecker, olive-sided flycatcher, yellow-bellied flycatcher, gray jay, boreal chickadee, winter wren, several types of thrushes, Philadelphia vireo, some 21 species of wood warblers, white-throated sparrow, Lincoln's sparrow, and a number of northern finches. The area is particularly noted for its excellent fishing, which includes brook trout, lake trout or togue, landlocked salmon, and whitefish.

Commercial Forest

The North Maine Woods was largely pristine wilderness until the land was first put up for sale in township units of 36 square miles when Maine separated from Massachusetts in 1820. Many of the original speculative purchases were by groups of individuals, and these joint ownerships—passing down from generation to generation, or sold to other individuals or groups—continue to this day. Forest products and paper companies began to actively purchase land

around 1900, but often the complex, undivided joint ownership patterns remained, with a township ownership consisting of a large corporation and many heirs (sometimes hundreds) of the original estates. Few people actually live on the land today, probably fewer than in the last century, and many of the small individual owners have their lands managed by private land management companies.

There are currently 20 landowners or landowner groups—about half of them industrial and forest products companies, the other half the heirs of the original landowners. (The State of Maine Bureau of Public Lands and Bureau of Parks and Recreation own roughly four percent of the northwoods.)

The undivided land ownership pattern operates by having the management costs (including taxes) taken from the timber harvesting and other commercial enterprise revenues, with the net profit or loss divided among the owners according to their percentage of ownership. Construction and maintenance of roads is done in conjunction with specific operations and is usually paid for by the owner conducting the operation; in areas of multiple ownership, costs are shared proportionally among the landowners.

This vast forest region was originally bought for its timber revenue potential and is actively managed for commercial timber production. Extensive portions of the region have been cut three times, occasionally in clear cuts, and today the fourth generation is being harvested. The owners refer to the land as a "great tree farm." However, this is not a tree farm in the sense of the single-species, even-aged plantations of the Southeast. The owners call it a tree farm to stress that it is not wilderness, but is a managed, commercial working forest.

The predominant coniferous forest species are red, black and white spruce and balsam fir. Spruce and fir regenerate naturally and very easily—indeed they reseed so easily that it is often difficult to create true plantations. The natural regeneration is so extensive that expensive preparation work is rarely necessary following cuts. One of the few operational needs is to thin out the new stands. While these forests are managed, therefore, less than 10 percent of the land is planted in coniferous species and much less than five percent is managed in a very intensive manner involving nursery-produced "super trees."

The vast majority of the area is reproducing naturally, either as predominant northern coniferous forest or on some soils as mixed forest containing conifers and northern hardwoods. The natural mixed forest consists of spruce, fir, white pine, some hemlock, red and sugar maple, beech, yellow and white birch, and aspen. There are also limited areas of rugged or inaccessible terrain that have not been cut.

Most people would likely consider this vast region a wilderness because there is no real development. Throughout an area twice the size of the State of Delaware, there are no towns, no motels, no restaurants, stores, gas stations, tow trucks, or services of any type. Users must be well-equipped and self-reliant as there are no rangers, lifeguards, etc. Yet the area has been cut over, it is actively managed for timber, and it is interlaced with logging access roads. The region is, therefore, not genuine wilderness. Nevertheless, it provides a unique backwoods experience for most of the thousands of recreationists and sportsmen who use the woods each year.

Managing Public Access for Outdoor Recreation

Prior to the 1950s, the area was largely inaccessible and public access for hunting, fishing, canoeing, camping and hiking was largely done on foot, by canoe, or by floatplane, often with the assistance of the professional guides and outfitters located in the towns outside the perimeter. After log drives on the rivers were prohibited, road construction increased dramatically to provide the infrastructure to move timber to the marketplace. An expanded system of private roads has been developed, totalling over 5,000 miles of permanently maintained gravel roads and several thousand additional miles of unmaintained temporary roads. Still, the primary purpose of the road system is for the transportation of raw materials, and visitors are advised that driving over 30 miles per hour is dangerous. Logging trucks have the right of way, with visitors required to pull over or off the roads.

The development of the expanded road system coincided with the boom in outdoor recreational activity, increased leisure time, and greater discretionary income that occurred in the 1960s. With more and more public demand for recreational access to these lands and the availability of access through the expanded road system, complex problems involving management of visitors arose.

The roads were constructed at the landowners' expense for timber harvest operations. Their use by private individuals caused many conflicts and problems over road erosion, safety, overcrowding and overuse of popular camping areas, rubbish and trash removal, and the ever present problem of forest fires. In order to deal with the growing number of such issues, the 20 landowner groups formed a nonprofit corporation or association, North Maine Woods, Inc., to develop a program to manage public use.

Access and Checkpoints

A technique was devised to control access to the woods through 17 checkpoints and 16 access roads, where visitors were required to register, pay fees for different types of use and obtain permits for campsites. Visitors were required to log in and out at the checkpoints on every visit, even if they had season passes. When the control program and fee schedule were initiated in the early 1970s, there was negative reaction from hunters, fishermen, canoeists and campers who had enjoyed free, unrestricted use. This huge area had always been used by recreationists and sportsmen and the quality of its hunting and fishing was widely known throughout the Northeast and much of the entire nation. While many landowners were not especially sanguine about public use of their private property, they recognized that such use was a tradition, that a number of professional guides and outfitters derived their livelihood from it, and that in any case attempts to limit it would create ill will and would be difficult and costly. Thus, some landowners had already developed their own systems of checkpoints, gates and permits, which were often cumbersome and conflicted with other areas. Now the improved, well-run and clearly-defined system is generally well accepted by the vast majority of the public and has become an efficient management tool in creating a unified, coherent order throughout the many landholdings.

User Fees

User fees allow the association to improve campsite access roads, construct new authorized campsites, prevent crowding and provide guidance to recreational visitors. Private landowners can concentrate on land management rather than on cleaning up after visitors. Revenues from the user-fee system have been used for a number of programs, including trash collection, public education, and campsite improvement, such as the installation of anchored steel firerings and the provision of picnic tables, and privies. The latest program involves controlling overuse by improving campsite access roads and securing shorelines by installing rip-rap. However, the fees do not cover all the management and operating costs for recreational use and the difference is paid for by the private landowners on a percentage of their ownership acreage.

Some 247 individual campsites are now available in 123 authorized camping areas. The sites are still primitive (there are no hookups) and widely spaced, and usually consist of space for a tent or recreational vehicle or pickup camper. Fires must be built in the steel firerings that are anchored in the ground. There is abundant dead and down wood for fires. Rock fireplaces are allowed only in certain designated areas and can only be used after obtaining a Maine Forest Service fire permit. There are usually privies and all sites now have rustic cedar picnic tables and 10 percent have primitive picnic table shelters.

Recreational Seasons

North Maine Woods is open for seven months of the year, from May through November. Since the system was instituted, there has been a slow but steady growth in visitor days from 121,000 in 1974 to 189,000 in 1984. The visitor days break down roughly as: 40 percent for hunting, 23 percent fishing, 13 percent visiting private, leased camps, nine percent camping, and nine percent canoeing. The remaining six percent is for picnicking, guided tours, and hiking. The various uses by month are concentrated accordingly: hunting in October and November; fishing in May and June; visiting private leases is uniform throughout the season; camping is relatively uniform with a slight peak in July and August; and canoeing runs from May through August, although it is highly variable depending upon the river flow.

NMW's summer season extends from the May opening to the end of September, and the fall season runs from late September through the end of November. The summer is a multi-purpose season, while the fall is primarily for hunting. During the hunting season, there are often quotas on the use of campsites to protect the area from overuse and to avoid crowding. Quotas are applied at other times to limit visitor pressure in especially popular areas.

All recreational visitors must register and pay various per person fees. Reservations are accepted, but must be made at least a month in advance. Those under 15 years of age, and Maine residents over 70, are admitted free. The fee system for other Maine residents is: $2.00 per day, $3.50 per night/camping, $12.00 for a day-use season permit, and $17.00 for an all-purpose season permit. Non-residents of Maine pay $3.50 per day, $4.50 per night/camping (with a $28.00 maximum for up to two weeks, when the daily fee resumes), and a day-use season permit with no camping for $28.00. The land use fee system

for the fall season is the same as for the summer season. There is a $5.00 fee for passing through checkpoints before or after hours.

There are also some 400 leased camps throughout the NMW, including about a dozen commercial sporting camps, with the leases negotiated by the individual landowners.

No mobile homes are permitted, single vehicles must be less than 24 feet long, and vehicles with trailers less than 44 feet long. Four-wheel drive vehicles are permitted only on roads and old rights-of-way. Trail bikes, motorcycles and all-terrain vehicles are not permitted. During the winter, there is free access for such activities as snowmobiling and cross-country skiing on unplowed roads, and ice-fishing.

Camping is not permitted for more than two weeks in any one location. Camping by backpackers and hunters is allowed in other than authorized campsites in certain areas, but an advance fire permit from the Maine Forest Service is required. Back country users are on their own; there are no marked trails except for the limited road system, so the use of topo maps is strongly advised.

Canoeing is one of the five major uses of the NMW. Passage to the state-owned Allagash Wilderness Waterway is available through four checkpoints and the prevailing daily fee of $2.00 or $3.50 is charged. Overnight camping on the Allagash is permitted only in authorized campsites, and is subject to special use rules.

There is considerable use of the Upper St. John River, which runs north for some 134 miles through the NMW. Seven checkpoints are available for access to the river. All canoeists must register, and must camp only at authorized sites. Firerings and picnic tables are provided at all sites, picnic table shelters and outhouses are available at some. Optimum canoeing conditions usually exist during May and early June, and about 70 percent of all canoeing takes place during the week around Memorial Day. NMW provides current reports on water conditions.

Public Education

One of the major problems and expenses in the area has been the removal of trash and litter. A major educational and management effort has been made to instill the spirit of "Carry In-Carry Out." There are disposal barrels at checkpoints and other areas, in addition to which visitors are provided with litter bags (some 9,000 in 1984) to help cart their trash out. NMW publications also remind visitors that under Maine law there is a maximum $100 fine for littering.

The association has maps of the North Maine Woods available for $1.00 and a waterproof brochure and map of the St. John River for $2.50. Other literature which is distributed free includes order forms for lake survey maps, a list of cooperating flying services, sporting camps, outfitters and professional guides, and Maine hunting and fishing regulations, etc.

Compared with Baxter State Park

This truly unique and innovative program, covering a vast area of private lands—as large as two Delawares or four Rhode Islands—and owned by a multitude of landowners, has proven to be an effective and practicable way of

using extensive primitive, undeveloped forested areas for the profitable provision of natural resources, while at the same time providing the public with ample opportunity to enjoy and experience low-cost environmental amenities—recreation, sports, fishing and hunting.

When one considers the cost of taking a family to a movie or a baseball game, one can appreciate the relatively low cost of this form of recreation. Furthermore, the fee structure is at least comparable to that charged at nearby or equivalent government-owned areas. Baxter State Park, located at the southern border of the North Maine Woods, is one of the largest state parks in the nation, covering some 201,000 acres. It was originally logged in its early history. Baxter charges $3.00 per night, per person, for a campsite with a lean-to or tent space, with a minimum fee of $6.00. NMW charges $3.50 per night, per person, with no minimum. Baxter admits children under seven years of age free; NMW is free under 15 years. Furthermore, Baxter State Park does not have reduced-rate season permits for overnight camping. Thus, not only is NMW comparable to state parks, but it is considerably less expensive after a visit of a few days or if a family has school-age children. Baxter has identical fees for residents and non-residents, but a stay by a single out-of-state visitor would be cheaper at NMW for any period over nine days, and Baxter charges an additional fee for out-of-state vehicles. Baxter recreational and camping opportunities are more extensive than NMW because some campsites have bunkhouses and cabins, and rental canoes are available. The Allagash Wilderness Waterway charges $2.00 per night for resident campers and $3.00 per night for non-residents, which is somewhat cheaper than NMW's fees for use of the Upper St. John River campsites. Baxter State Park has averaged 107,896 visitor days over the past four years, which covers a year-round season, including a restricted-use winter season.

As noted, NMW does not cover all its associated management costs through the current fee structure, but the owners believe the losses are reasonable and are helping to make an important contribution to the state by accommodating and managing public recreation use.

A Partnership

North Maine Woods calls itself a "Multiple Ownership Area under Multiple Use Management." They state: "It is an organization. Landowners—big and small—corporations, individuals, and families have joined with Maine's natural resource agencies in a partnership to solve today's problems and plan the wisest multiple use management for the future. It is a spirit. Past and present; man and nature meet here. Men who make their living from the woods and men who relax here love this area. And through North Maine Woods, they work together to see that while they take forest products, fish, wildlife, and pleasure from this great region, they take nothing that will make it any less in the future than it is today."

The North Maine Woods association is trying not to encourage increased use of the land and does not publicize or advertise. It does not want to increase recreational demand, but is willing to accommodate the public that comes to the area. Because the land and roads are used primarily for timber production, increased use would only lead to more serious problems: it costs a lot of money to keep the logging roads safe and at the same time manage their use by

thousands of visitors. The landowners are sharing their land with the public as a gesture of goodwill to recreationists. NMW must also work with U.S. and Canadian Customs and the U.S. Border Patrol to prevent passage through the area into Canada, and to see that Canadian visitors leave by the same border entry points they entered.

This successful approach to many complex use and management problems has demonstrated that economic development, environmental protection and outdoor recreation can be compatible. This is especially true, and important, in Maine where the vast majority of the land is under private ownership. A mere 136,000 acres are owned by the federal government, which amounts to only 0.685 percent of the land area of the state—the third smallest percentage in the nation, and underscores not only the importance but also the significant contribution that the private sector can and does make to the protection of natural resources and the provision of recreational opportunities. North Maine Woods is playing a vital role in the protection and maintenance of America's unique natural heritage. [North Maine Woods, Inc., P.O. Box 382, Ashland, ME 04732]

Wildlife Sanctuaries, Preserves and Research Foundations

This category includes both nonprofit and profit-seeking organizations involved in the conservation of wildlife and habitat. Although relatively few in number and small in size, such groups have made significant, often unique, contributions to the direct protection of wildlife and habitat. Their existence has facilitated important research on the management of wildlife and wildlife habitat on private lands, especially on farmland, ranches and timberland. These organizations are funded and operated in a wide variety of ways.

CASE STUDY: HAWK MOUNTAIN SANCTUARY ASSOCIATION

The Hawk Mountain Sanctuary Association is a private, member-supported, nonprofit organization. The Association was incorporated in 1938 to maintain Hawk Mountain Sanctuary, which had been established in 1934 to foster the conservation of birds of prey, as well as to create better understanding of the natural environment. Hawk Mountain Sanctuary celebrated its 50th anniversary in 1984.

Annual membership dues range from $10 for an individual and $15 for a family, up to $300 for a patron. (All dues and contributions are tax deductible.) Current membership is about 6,700, about 15 percent of which is made up of corporate sponsors and patrons. Members receive the Association's semi-annual magazine *Hawk Mountain News*, other special communications, and discounted rates for educational and most special events.

The Association's annual budget in 1984 was $298,000 and will exceed $300,000 in 1985 (a decade ago it was $85,000). The increased budgets of recent years are largely the result of a growing membership and increasing private contributions. The Association maintains an invested reserve fund of more than $500,000, mostly from large bequests. The investment income is used to help support regular operations; the principal may be used for capital purchases,

such as a recent addition of 185 acres to protect the core of the Sanctuary.

Hawk Mountain Sanctuary consists of a 2,000-acre wildlife refuge with associated visitor/education facilities. It receives about 50,000 visitors per year. Entrance is free to members, others pay $2.00 for adults and $1.00 for children. It is open 365 days a year. The Sanctuary preserves a block of unbroken deciduous forest in the Appalachian Mountains, and it is home to such species as ruffed grouse, wild turkey, white-tailed deer, and red and gray fox. It is particularly noted for its fall migration of birds of prey and many other species. There are impressive thickets of mountain laurel and rhododendron. A marked trail, three-quarters of a mile long, leads to various observation points and to the popular North Lookout, which at an elevation of 1,500 feet, rises 1,000 feet above the Little Schuylkill River. The Sanctuary is now a Registered Natural Landmark and the Appalachian Trail runs adjacent to the property. (In 1982, 100 acres were sold to the federal government, containing that portion of their property crossed by the trail.)

Hawk Mountain is a promontory atop the Kittatinny Ridge of the Appalachian Mountains, located in eastern Pennsylvania. The combination of prevailing winds and mountain topography make it one of the superb bird-watching spots in the world. Especially in the autumn, from mid-August through November, large numbers of raptors—hawks, falcons, ospreys and eagles—migrate south along the mountain ridges. Raptors from much of northeastern North America follow the ridges, as do many other species of birds. Occasionally, there are spectacular concentrations of broad-winged hawks early in the season; the all-time, one day tally was 21,488 raptors, mainly broadwings. However, the average fall count is about 20,000 birds of 14 species.

Prior to the creation of the Sanctuary, hunters, gunners and "sportsmen" gathered on the ridge tops in the fall to shoot the migrating hawks for sport. Over the years, untold thousands of raptors were slaughtered as they passed down the mountains of eastern Pennsylvania, and Hawk Mountain, in particular, became a favorite shooting spot. The shooting was so heavy that one man collected the spent shells for scrap brass. As early as 1900 a few local conservationists had begun to work to halt this slaughter, but birds of prey were still considered vermin or "chicken hawks" which preyed on "good" birds, and there was little support for these efforts. During World War I, in fact, these conservation efforts were viewed as suspiciously "pro-German" because they deprived American boys of the opportunity of shooting at live targets.

By the late 1920s, there was mounting concern about the slaughter. George M. Sutton, then the Pennsylvania State ornithologist, first drew the attention of conservationists and professional ornithologists to the issue when he published two articles in a professional journal. Richard H. Pough, an amateur ornithologist in Philadelphia, visited the Mountain in the early 1930s, and began to spread the story of the raptors' plight to a broader conservation and birdwatching audience.

Mrs. Edge's Protection Efforts

The founding spirit behind the creation of the Sanctuary was Mrs. Rosalie Edge, born in 1877. She was a relative of Charles Dickens and James McNeill Whistler, a leading suffragette, and one of the nation's first prominent

conservationists. She conducted successful campaigns to expand Yosemite National Park and to create Olympic National Park and Kings Canyon National Park.

Rosalie Edge became an avid birdwatcher in the New York City area where she became acquainted with the noted zoologist Willard Gibbs Van Name and the staff of the American Museum of Natural History. She soon came to share their concern about the rapid loss of birdlife to "sportsmen" and market hunters, and became especially concerned about vanishing species and the number of species that had recently become extinct. She assailed the bird protection organizations of that time for not doing enough. In 1929, she formed the Emergency Conservation Committee and began an active campaign criticizing the "conservation establishment," including the National Association of Audubon Societies, the U.S. Biological Survey, and state game departments, as being too closely associated with the hunting establishment, sportsmen and ammunition manufacturers. She argued that these organizations were mainly concerned with the plight of game species: waterfowl, gamebirds and shorebirds. She maintained that with a few exceptions, notably the spectacular wading birds such as egrets, and songbirds, they were relatively indifferent to the fate of many other species.

Richard Pough and his friend Henry H. Collins, Jr., first visited Hawk Mountain and witnessed the slaughter in the fall of 1932, and Collins presented a paper on the situation to the Hawk and Owl Society, an affiliate of the National Association of Audubon Societies (NAAS). In August 1933, the Emergency Conservation Committee met with the NAAS, and Mrs. Edge urged Audubon to purchase Hawk Mountain to halt the slaughter. In October, Pough and Collins brought the issue up before a joint meeting of the NAAS, the Hawk and Owl Society, and the Linnaean Society in New York City, and Audubon was again urged to purchase the area. Mrs. Edge and others thought Audubon would take action.

In June of 1934, Rosalie Edge contacted Richard Pough to find out what the NAAS had done. It had done nothing. Mrs. Edge then determined to take immediate action herself to see that not one more fall slaughter took place. She asked Pough to meet her at the mountain the following Sunday and to bring along a local real estate agent. She was informed that 1,398 acres were available for purchase at $2.50 an acre. She leased the area for one year for $500, which she borrowed from Willard Van Name (later forgiven), and obtained an option to purchase the property for $3,500.

In August, Mrs. Edge asked a young naturalist in Vermont, Maurice Broun, to move to Hawk Mountain to become its first warden and to post, patrol, and guard the sanctuary, but to keep the information confidential in order to prevent the hawk shooters and the NAAS from learning about it. Broun accepted and arrived for duty on September 10, 1934. He began posting the property the following day, and Mrs. Edge's hawk conservation efforts were underway. As Mrs. Edge wrote to Broun: "There has never been such a thing as a Hawk Sanctuary—as far as I know—and I believe there is no other such place for the observation of hawks as this mountain." Broun viewed the job as a temporary assignment and refused to accept a salary in 1934. He stayed on until 1966 as the first curator.

Following this initial success, the rift between Rosalie Edge and the Audubon

Association widened, as she became determined to raise the money for the purchase of Hawk Mountain and to manage the Sanctuary with complete independence from the Audubon Association or any organization associated with it. In October 1934, she stated her concerns to the Hawk and Owl Society:

> "The indifference of the Audubon Association to hawk protection, the fact that in certain of its publications it recommends the pole-trap and that it uses steel-traps on its chief sanctuary; that it believes in the 'control' of many valuable species and in general urges the protection only of the 'birds of lawn and garden' makes it undesirable that the Audubon Association shall have a controlling voice in the policies that shall regulate the sanctuary at Hawk Mountain."

Over the following year, as Mrs. Edge rushed to raise the money to meet the deadline on her purchase option, the fight to prevent control by Audubon grew bitter, and many friendships were strained. But finally, in December 1935, she raised the last of the $3,500, and following two years of land title clearances, the Hawk Mountain Sanctuary Association was incorporated in 1938 to hold and manage Hawk Mountain.

With the Sanctuary secure, Mrs. Edge and her conservation associates had taken the first steps to protect the nation's birds of prey. The first year was largely spent in posting and patrolling the Sanctuary. By the second year, birdwatchers and naturalists began to arrive, and the sport of hawkwatching and hawkcounting began. The maximum number of visitors on one day in 1935 was 193. In 1936, it reached 540. However, through the first few decades, there were seldom more than a hundred people gathered on the lookouts. Today, daily crowds sometimes exceed 3,000 as they come to the mountain during fall migration to view the spectacular hawk flights. In 1984, visitors came from 44 states and 25 foreign countries. Detailed counts of the hawk flights have been maintained from the first fall, with the exception of three years during World War II.

Changed Public Attitudes

One of the major conservation efforts of the Association was undertaken through educational programs to change public attitudes toward birds of prey and to obtain legislative protection for all raptors. Prior to the creation of the Sanctuary, most raptors were considered pests and vermin. Many state governments and state game associations encouraged the shooting of hawks in order to protect gamebirds and poultry. Very few species were protected. On the contrary—in 1934 it was not only legal to shoot any species of hawk in Pennsylvania, but there was also a state bounty on the goshawk. At the peak of the bounty period, Pennsylvania paid some $90,000 for hawks that may have killed $1,875 worth of chickens. While a few chickens may have been saved, conservationists also estimated that farmers lost nearly $4 million in grain crops because of increased rodent populations resulting from the decreased number of hawks. While these early cost-benefit estimates were certainly crude and unreliable, they did begin to make the argument for the beneficial and economic importance of raptors.

The Hawk Mountain Sanctuary Association and other conservationists continued to work for the protection of the state's raptors over the years. In 1937 a

law was passed protecting all hawks except accipiters, although it was not enforced. In 1951 the state ended the bounty on goshawks. In 1957 Pennsylvania passed a law protecting all hawks during fall migration in the northeastern part of the state. And in 1970, the state gave complete year-round protection to all hawks, eagles and owls, except the great horned owl. By then, the environmental era was in full swing, and finally, in 1972, the federal government extended full protection to all birds of prey in the United States under the Migratory Bird Treaty Act.

Hawk Mountain Today

Over the past half century, the Hawk Mountain Sanctuary Association has grown from a small unpopular effort to stop the slaughter of "predatory" birds on the mountains of Pennsylvania, into an internationally known, year-round, wide-ranging conservation, education and research center. From a staff consisting of one volunteer warden, it has grown to include seven full-time and two part-time employees, plus seven to 10 interns each year, and a cadre of 60 to 100 seasonal volunteers.

Workshops and Seminars

There is a Visitors Center, with interpretive educational displays, including many raptor species and art exhibits, a bookstore, and an education center which is used for classes, meetings and conferences. There is a regular fall lecture series as well as additional education programs, workshops and seminars. Special programs have been developed for visiting school children who number several thousand annually.

In recent years, Hawk Mountain has undertaken a national effort to provide college students, naturalists, and the general public with a better understanding of the role and importance of raptors in the ecosystem and the consequent need for conservation programs. In 1975, a program was begun for undergraduate and graduate students offering internships accredited by Cedar Crest College in Allentown, Pennsylvania. These include participation in the Sanctuary's educational and sanctuary management programs, as well as a wide range of independent studies in conservation and research. More recently, in affiliation with local colleges, Hawk Mountain has established an outdoor classroom, offering full college credit for courses in ecology, environmental studies, botany and ornithology, with most courses held at the Sanctuary and some involving field excursions to other areas. These courses are especially popular with school teachers in need of in-service training credits.

Other recent Association activities include: a raptor recovery program in conjunction with the U.S. Fish and Wildlife Service and the State of Pennsylvania to care for injured hawks, eagles, and owls and return them to the wild; trips combining conservation education and field studies of birds of prey to some of the major raptor observation areas in this country and abroad, including the Birds of Prey Natural Area along the Snake River in Idaho and Eilat, Israel; and serving as a national repository for hawk migration data. In 1983, Hawk Mountain cooperated with the California Condor Recovery Program to develop more effective public education and awareness programs about condors. Thus,

Hawk Mountain is helping generate the vital support needed from local ranchers, farmers, and landowners to carry out this important national effort to preserve one of the nation's most endangered species.

The history of Hawk Mountain Sanctuary offers a striking example of the role of private initiative in achieving major accomplishments in wildlife conservation. The perseverance and single-mindedness of a very small group of concerned individuals enabled the pioneer organization to spawn national and international efforts to educate the public about the ecological importance of birds of prey, and to further efforts toward their conservation, including tireless work to obtain the passage of legislation to protect these important species.

Rosalie Edge was often difficult to work with and was an irritant to many leading conservationists of her day. But she persisted in her belief that it was a fallacy to carry out piecemeal conservation or that there were "good" birds and "bad" birds, and she stuck to her principle to conserve nature whole. Ten years after her death in 1962, there was finally complete federal protection of all birds of prey. The sport of raptor shooting had largely vanished and been replaced with the sport of hawkwatching and hawkcounting. The shotgun had given way to binoculars. Now, across the country, and increasingly in many spots throughout the world, professional and amateur ornithologists, naturalists and nature lovers gather to view and document the passage of raptors at key spring and fall migration concentration sites.

Raptor Research

Prior to the accomplishments and proselytizing of the Hawk Mountain Sanctuary Association, there had been very little scientific or popular interest in raptors or knowledge about their ecology, population sizes, and migrations. However, raptor biologists have since become an important wing of the wildlife conservation community. There are now numerous private organizations dedicated to the conservation, protection, restoration and rehabilitation of raptors.

The Raptor Research Foundation, Inc., was created in 1966 by raptor specialists to disseminate information and promote a better understanding and appreciation of the value of birds of prey. It has nearly 800 members, mainly in the United States, but also representing 25 other countries. There are raptor organizations in most European countries, the Soviet Union, and Israel, and the International Council for Bird Preservation has a World Working Group on Birds of Prey. These groups all have annual meetings and publish newsletters, journals, conference proceedings, and special reports.

The Hawk Migration Association of North America was founded in 1974 to advance the knowledge of raptor migration across the continent and to monitor raptor populations as an indicator of a sound environment. It monitors migration counts at over a hundred hawkwatching sites throughout the United States and Canada. This organization and Hawk Mountain have begun to computerize the growing data from hawk counts in order to create a data base to determine such things as long-term population trends. The nearly 50 years of consistent, systematic, daily, season-long records from Hawk Mountain are a wealth of research information. The Hawk Mountain records are especially important because it is the only data spanning the years before, during, and after the widespread use of DDT.

Many individuals and private organizations, and some governmental agencies, are actively involved in captive breeding of raptors to maintain rare and endangered species and to restore them to the wild. Private breeders provide birds to government agencies for release in various areas. Other individuals and groups are engaged in the rehabilitation of injured raptors. And such species as the peregrine falcon, bald eagle, and osprey, which suffered serious population declines as a result of the widespread use of certain pesticides, are now recovering as a result of the federal ban on DDT in 1972 and through the concerted efforts of a great many individuals and private organizations working independently and in cooperation with governmental recovery and reintroduction programs.

Many industry groups and corporations have also made contributions to the protection of birds of prey. The Edison Electric Institute worked diligently to come up with solutions to the problem of raptor electrocution along distribution lines in the western states, and it also coordinated the development of artificial nesting platforms for a number of species. These efforts were undertaken to prevent the death of protected birds of prey as well as to prevent power outages that affected the reliability of the electric distribution system. Utility companies have supplied power poles for the erection of nesting platforms for ospreys, peregrines and eagles.

The mining industry is also cooperating with raptor biologists to create artificial nesting sites adjacent to and on the sides of mine pits and highwalls in the West. Throughout vast stretches of relatively treeless areas in the West, natural cliff faces are usually the main place for eagles, falcons, and hawks to nest. Standing highwalls are often rapidly utilized by raptors for nesting sites as they provide additional breeding habitat. When raptors construct nests on highwalls of active mines where disturbance might prevent successful breeding, or where reclamation laws require the elimination of the highwalls, the young birds are relocated to artificial nests, usually on nesting platforms atop poles and occasionally on huge man-made rock piles, placed in appropriate areas at a distance of 100 to 600 yards from the original highwall nests. In Wyoming a number of pairs of golden eagles have successfully been relocated to the alternative man-made structures. Because many raptor biologists believe that highwalls provide unique raptor breeding habitat and increase habitat diversity, a number of variances have been issued for alternate reclamation programs allowing experimental highwalls to remain in order to maintain the continued nesting of raptors or to permit the excavation of nesting cavities on the highwalls to attract birds or for the purpose of introducing or "hacking" young raptors such as prairie falcons to the site in the hope of establishing nesting pairs.

Other companies have made and distributed nestboxes for cavity-nesting raptors. Many other businesses have made monetary contributions to raptor protection organizations.

A number of conservation organizations now have major programs for the conservation and protection of birds of prey. Notable among them are the National Wildlife Federation, the National Audubon Society, and various state Audubon societies. A growing number of universities have raptor management and conservation programs.

Hawk Mountain Sanctuary celebrated its 50th anniversary with a Golden Anniversary Week (October 8–14, 1984), bringing together leading raptor

specialists, ornithologists, scientists and naturalists from across the country and many foreign nations to honor the achievements of Rosalie Edge and her Association. A part of the program was an international symposium on "Raptor Conservation in the Next 50 Years." Coincident with the program, the federal government designated the week "National Birds of Prey Conservation Week," and there were many educational programs conducted in various parts of the country. This was a fitting tribute to the vision and foresight of Mrs. Rosalie Edge and her belief in "the interdependence of all living things."

The efforts of Mrs. Edge and her associates to protect birds of prey contributed to a revolution in the way that conservationists and naturalists view nature. These efforts also helped to create the important insight that as predators at the top of complex food chains, raptors are indicators of environmental quality and their populations reflect environmental changes. Information gathered from raptor specialists, hawkwatchers and counters led to the awareness in the early 1960s of the plight of, and rapid decline of, many raptors suffering from pesticide contamination and helped create a national consensus around environmental protection. Equally important, and more encouraging, have been the recent hawkcounting data suggesting a recovery, or at least a stabilization, of these formerly declining species—a sign that we have begun to see an improvement in important aspects of environmental quality. [Hawk Mountain Sanctuary Association, Route 2, Kempton, PA 19529]

CASE STUDY: SEA LION CAVES, INC.

America's largest sea cave, the Sea Lion Caves of coastal Oregon, is a for-profit organization that protects the only mainland rookery of Steller sea lions.

The sea lion caves were discovered in 1880 by Capt. William Cox. He purchased the area from the State of Oregon in 1887, and the property remained in his family until 1926. The land was purchased by R. E. Clanton in 1927 with the intention of opening it as a business. Following the announcement of plans to open U.S. Route 101 in 1930, Clanton was joined by J. G. Houghton and J. E. Jacobson. They constructed a 1,500-foot trail along the cliff face and a 135 stair-step tower down to the cave entrance. Sea Lion Caves was opened to the public in 1932. Clanton withdrew in 1934 and R. A. Saubert joined the partnership. After World War II, ownership passed to the partners' sons.

In 1961, a 215-foot elevator, designed by Otis Elevator Company, was constructed to descend into the cave, and tourism increased markedly. The caves consist of a large, domed central cavern, about 125 feet high, with a floor area of about two acres, and three natural passages connecting the cavern to the outside. Two of the passages are sea-level entrances, with one extending about 1,000 feet. These allow passage of water, sea lions and sea birds. The walls of the cavern are various shades of green, buff, purple, pink and red from growths of lichens and algae, and mineral stains. In size and beauty, the caves are reputed to be comparable to the Blue Grotto of Capri in Italy.

The caves and adjacent rocks are the only known mainland rookery (breeding area) and hauling area (wintering area) of the Steller sea lion. Approximately 200 Steller sea lions are resident and use the caves as a rookery. Twenty to 50 California sea lions congregate there in the fall and winter. As the wild sea lions freely come and go, daily counts vary considerably. Maximum counts of

both species run as high as 600 animals. Harbor seals and northern fur seals do not use the caves, but are sighted on beaches in the vicinity.

The cave and rocks also serve as an important sea bird rookery. The most common species is the Brandt's cormorant; U.S. Forest Service counts of 2,500 nests make it the largest Brandt's cormorant rookery in the world. Approximately two dozen pairs of pelagic cormorants and two dozen pairs of double-crested cormorants also nest there. About 100 pairs of pigeon guillemots nest inside the cave. Three species of gulls regularly utilize the area. The western gull is the most common, with a breeding colony of about two dozen pairs. A slightly smaller number of herring gulls also nest there. The California gull is an uncommon non-breeding visitor.

From the top of the headland above the caves there is an ocean view of almost 20 miles. This has become a favored observation point for viewing whales. The endangered gray whale passes near shore in spring and fall migration and some non-breeders summer in the area. Killer whales also are seen.

The Sea Lion Caves property is situated on about 125 acres of rocky coastal headlands. Development has been kept to a minimum, consisting of about 20 to 25 acres used for access roads, parking lots, administrative buildings and a gift shop. The rest of the site consists of natural groundcovering vegetation and forests, which serve as a buffer with adjacent landholdings. Careful efforts have been made to maintain the site in its natural condition.

Sea Lion Caves has become a major tourist attraction on the Oregon coast and receives over 200,000 visitors annually. The heaviest tourist season is from the first of May to the end of September, although the caves remain open throughout the year. The daily entrance fees are $4.00 for adults and $2.50 for children aged 6 through 15. There is a permanent staff of 15 employees and, during the peak summer season, an additional 25 employees are hired. As a profit-making enterprise, Sea Lion Caves pays taxes.

Sea lions along the Oregon coast once numbered more than 10,000. Over the years, however, they were greatly reduced in number by bounty hunters, sports hunters and a few commercial hunters, until only about 1,000 were counted in a 1964 U.S. Fish and Wildlife Service survey. Since 1972, sea lions have been fully protected by the federal Marine Mammal Protection Act. By 1976–1977, there had been a recovery in the Steller's population to around 1,400. The most recent aerial surveys indicate that there are now about 4,000 Steller sea lions in Oregon.

Commercial Hunting

Commercial hunting of the sea lions had always been very limited, mainly because the Steller sea lion did not have a commercially valuable fur pelt. There were limited attempts to exploit its hide for the leather trade, to utilize its oil and whiskers, and to process its meat for human consumption and for fish bait. But these industries never became viable.

The major threat to the various sea lions and seals has been their reputed threat to the important commercial fishery and sports fishery, especially for the commercially valuable salmon. Seals and sea lions feed primarily on fish. Not only was it argued that they consumed substantial quantities of salmonids, but also that they drove spawning runs away from the mouths of rivers. They

also cause damage to nets through entanglement, and to lines, traps and fishing gear. They further reduce the value of the salmon catch by taking bites out of fish caught in the gillnets.

By the mid-1800s, the commercial fishing industry had come into conflict with the pinnipeds. During the period from 1890 to 1920, the commercial salmon fishermen and the canneries not only began to kill seals and sea lions, but hired professional hunters to harass them and kill them within the river mouths and on their breeding islands. William Hunter was the most noted bounty hunter and reportedly killed some 10,000 seals and sea lions along the Oregon and Washington coasts from 1914–1920 for the commercial fishing industry.

Beginning in the early 1900s, the commercial fishing interests prevailed upon the State of Oregon to declare a $2.50 bounty on seals and sea lions. In 1920, the state legislature requested the State Fish Commission to exterminate the entire population of seals and sea lions along the Oregon coast, which was estimated to be about 3,000. The state imposed a system of special taxes on the commercial fishing industry in order to raise revenues for the bounty program of $5.00 each for seals and sea lions. William Hunter became the chief bounty hunter and collected $5,000 during 1921. Seven other bounty hunters collected another $5,000 in the first year. The mammals taken by the bounty hunters were increased by a considerable amount of sports shooting throughout the bounty period, continuing until fairly recently.

Protective Legislation

However, conservationists and a major segment of the tourist industry in the 1920s began to lobby for protection of sea lions. The tourist industry was split over the sea lion question. That part of the industry dependent upon sports fishing, especially for the anadromous salmonids along the major rivers, wanted a bounty on seals and sea lions they viewed as a threat to the salmon and steelhead fishery; that part of the tourist industry dependent upon nature buffs and people interested in marine life wanted strict protection.

In 1925, the conservationists prevailed upon the State Fish Commission to reduce the sea lion bounty to 50 cents, while leaving the bounty on seals at $5.00. This effectively extended protection to the sea lions, which were becoming a major tourist attraction because they were permanent residents, hauled out on accessible rocky headlands and islands, and were large and noisy. The seals were less important for tourism since they were not as striking and the fur seals were only winter visitors.

By 1931, the conservationists and pro-pinniped tourism promoters had succeeded in getting legislation passed to protect sea lions, except in specially designated areas, usually around the mouths of the 10 major rivers with salmon and steelhead runs, where the commercial fishing industry and the sports fishing industry had a powerful voice. Throughout the 1930s and 1940s, efforts were still made to eliminate sea lions in these areas, and, as late as 1950, the State Fish Commission hired a person to harass and destroy the sea lions entering the Umpqua River. Efforts to eliminate seals continued, especially at the major river mouths, until the passage of the Marine Mammal Protection Act of 1931. From 1936 until 1971, Oregon paid bounties and hired hunters to

control or reduce seal populations, especially within the Columbia River, where bounties ranged from $5 to $25 per seal and where over 3,600 seals were killed.

The non-sports fishing tourist industry along the central Oregon coast, together with the conservation community, played a major role in sea lion protection. As early as the 1920s, they had argued that the stench from sea lion carcasses killed by the bounty hunters was driving tourists away. And during the 1931 campaign to protect the sea lions, the Port Orford Chamber of Commerce played a prominent role in calling for their protection as a tourist attraction. It is notable that the state's 1931 Protection Act extended special protection to all sea lions in Lane County, allowing no exceptions for designated kills. It was probably not coincidental that Sea Lion Caves is located in Lane County and that in 1932 the Caves officially opened as a full-fledged tourist business based entirely on the sea lions.

The careful, self-interested, private protection of this important sea lion rookery located on private property was especially important at the height of the bounty-hunting period. The depletion of the sea lion population was particularly heavy during the 1920s and during the early years of the Great Depression when a number of noted bounty hunters made their living that way. The original and subsequent owners of Sea Lion Caves spent much of their time driving them off.

Recent studies have shown that seals and sea lions probably consume a very small percentage of the salmon run and that salmon also make up a very small percentage of their overall diet. Nevertheless, feelings still run high in an industry facing rising costs and regulations, increasing competition, and overfishing. Even after the ending of sea lion bounties, local residents would still shoot them for sport or as a nuisance, and it is reported that illegal shooting of pinnipeds still occurred as late as 1977. However, since the passage of the Marine Mammal Protection Act, all legal sea lion and seal killing and control programs have ended, and their populations are relatively safe. Official counts within the state appear to be increasing and Sea Lion Caves believes that their population has been increasing over the past four to five years.

Scientific Studies

Sea Lion Caves is not only a major tourist attraction, it is also an important research location for naturalists, scientists, and students of geology, ornithology, marine biology and natural history. It is especially noted for its protection of the marine life. The sea lions in their natural habitat are not disturbed. Visiting tourists are fenced out, but the resident mammals are not fenced in as in a zoo, aquarium or marine animal park.

Scientific studies have been conducted on the rookery because of its accessibility and protection. Sea lions had received little scientific study until Dr. Bruce Mate, of the Oregon State University Marine Science Center in Newport, did his doctoral dissertation on them in the late 1960s. He conducted research at Sea Lion Caves for almost three years because it was one of the few readily accessible areas where year-round observations could be made. Among his findings was the fact that there was considerable travel and interchange between sea lion rookeries. Sea lions that he had tagged on islands off Coos Bay, 66 miles to the south, showed up at the Sea Lion Caves, further strengthening

the argument for the importance of the many decades of protection afforded the colony at Sea Lion Caves.

The caves also play an important educational role for the public by introducing adults and school children to sea lions and to their place in the marine environment. People who have visited the rookery and have watched the entertaining pups are certainly less likely to maintain cavalierly that they should be eliminated because they prey on fish.

The Lane Humane Society of Eugene, Oregon has praised the continuing wise stewardship of the area. In 1977, Oregon Governor Robert W. Straub wrote that the property was "one of Oregon's great tourist attractions as well as a great and natural resource." He also praised its operation because "A private organization has shown that it can, by using a combination of common sense and good management, develop and protect such a great resource and attraction—and still show a profit." The owners report:

> "Had not the area been privately owned, developed, and protected, especially in the early days when the State of Oregon paid a bounty for slaughtered sea lions, the Sea Lion Caves' area would undoubtedly be void of sea lions and other marine life, and the natural wonder would probably not exist today. The owners and managers are proud of the facility and hope that you enjoyed your visit. Our basic goal is to maintain the resource, keeping it as natural as possible but still making it easily accessible for everyone.
>
> "Our existence at Sea Lion Caves is totally dependent upon the wildlife in the area and the cave, so we take every precaution possible NOT to disturb the natural lifestyle of the animals in any way, and still make it accessible to the public for observation."

Given the plight of the sea lions for so many years, the great reduction in their numbers, and their possible near brush with extinction, the current owners are especially proud of what the original owners accomplished—practicing conservation well before it became fashionable, and well before the Sea Lion Caves began to return a profit. Their continued investments in the property were considered risky, if not foolhardy. But Sea Lion Caves demonstrates that given special conditions and perseverance, making a living and preserving wildlife are not mutually exclusive. [Sea Lion Caves, Inc., 91560 Highway 101, Florence, OR 97439]

Hunting and Fishing Clubs, Camps and Ranches

American sportsmen, hunters and fishermen, have long been recognized for their role in the conservation of wildlife species and in the protection and management of wildlife habitat. Many of the national wildlife refuges in the eastern United States include formerly private duck clubs. While duck clubs exist primarily to hunt waterfowl, they also protect wetland habitat for breeding, migrating and wintering waterfowl, prevent wetlands from being converted to other uses, and provide critical habitat for a wide range of non-game species.

Many of these clubs also pay substantial property taxes based on high

agricultural or recreational land rates. In some areas of the country duck clubs maintain some of the last remaining wetlands in regions where agricultural demands are rapidly depleting the supplies of fresh water. Their significance is evidenced by the fact that there are some 11,000 duck clubs protecting from 5.2 to 7 million acres of wetlands in the U.S., while the entire National Wildlife Refuge System, outside of Alaska, includes only 4.7 million acres of wetland.

Hunting preserves and game ranches play a growing role in the protection of wildlife habitat and the protection and propagation of many rare game mammals, including a number of non-native species which are threatened in their native countries. Cattle ranches and farms that are having an increasingly difficult time turning a profit are turning to game ranching as a profitable sideline. In some areas, bird hunting and big game hunting have become so attractive that they are replacing intensive domestic animal ranching and grain farming. This in itself is a net gain for wildlife because it relieves habitat destruction from overgrazing by domestic animals and from planting roadside-to-roadside agricultural crops. The use of potentially harmful agricultural chemicals is also reduced. Game animals, both native and exotic, often do less damage to grasslands and brush, and require less care and management. The recovery of native wildlife habitat also provides a substantial benefit for non-game wildlife, restores biological diversity, and even provides habitat for rare species. Furthermore, a preserve that maintains populations of some foreign species can protect their gene pools and serve as a modern Noah's ark for species which may become threatened in their native countries through development pressures.

CASE STUDY: WORD HUNTING RANCH, INC.

This former intensively-managed cattle and grain ranch is now being converted back to wildlife habitat and a hunting ranch for ring-necked pheasant and deer.

Like many another rancher, Don Word and his four sons had been faced with the growing unprofitability of his cattle ranching business and grain production. In spite of ever more intensive farming, the doubling and tripling of cattle herds, and plowing from fence row to fence row, profits continued to decline. Word also noted that as the farming became more intensive, the wildlife, and especially the pheasants, disappeared. As the hedgerows and edge habitat disappeared, so did the pheasants. That area of South Dakota had formerly had some of the finest pheasant hunting in the nation.

In the early 1980s, Don Word sold off most of his cattle and began to replace them with pheasants and to improve the wildlife habitat, hoping this would also restore the native deer population. He believed that he could make more money by charging hunters for access to the game on his property than he could by remaining in the livestock business.

"We lost so much money on cattle, it was just a matter of time before we'd have to give it up," Word said. "The old ring-neck is king. I'm not so sure but what the dadgum pheasant isn't worth more than grain and cattle."

Word and his sons have two ranches located in the open prairie lands of southwestern South Dakota, not far from the Badlands, and the Big White River runs down between them. The property, which is a little over 7,000 acres, has been converted to wildlife habitat. Fields of wheat, milo, native weeds and

grassy river bluffs overlook the tree belts lining the river. Word has leased two areas of 6,000 acres and 2,000 acres which he also plans to manage for hunting.

The first step was to sell off most of the cattle, although they still own 300 head. Special attention was given to restoring and protecting river edges and bottomland where he planted clover, some wheat, and especially milo, which remains unharvested as food and shelter for wildlife. Furthermore, he uses no pesticides and chemicals in order to encourage insects and natural vegetation to thrive. According to a report by the Wildlife Management Institute, Word says, "The habitat has come back like you wouldn't believe. This is still a working ranch, but we've got more hunters now than cowboys."

Word has noted some pleasant side effects to having plenty of pheasants around, "We had a grasshopper problem this year, and you know, the pheasants just took care of it. They eat those grasshoppers like crazy."

Together with the reduction in cattle grazing and grain production and the restoration of wildlife habitat, Word began to stock the ranch with ring-necked pheasants to build up the former population. He purchased 10,000 birds at eight weeks of age from a private hatchery in South Dakota. Six thousand of the pheasants were released early in the year, in advance of the hunting season, to help bolster the natural population and to acclimatize the birds. The Words go out with dogs to work the birds so they become wild, to enable patrons to get a genuine hunting experience rather than some artificial release and shoot hunting. The other 4,000 birds are held in reserve in holding pens to release as the season progresses.

Pheasant Hunting

Because of his program of releasing captive-bred pheasants, Word's ranch qualifies for a State Fish and Game hunting preserve license, which allows pheasant hunting much longer than the regular pheasant season. The regular season runs from 20 October through 7 December. Word is able to provide hunting from 1 September through 31 March. The extended season, and especially the winter hunt, are bringing him attention and customers from across the country. The Ranch also has a limit of five pheasants per day, while the state limit is three birds per day.

This is Word's second year of operation; the first was mainly promotional. His first winter hunt during early 1984 immediately brought repeat hunters in the fall of 1984 — some from as far away as Georgia. The Words hope to be able to make a viable operation of the game ranch, especially as word of their operation spreads and as hunters learn about winter pheasant hunting. Within 10 years they hope to have hunters and their families from all over the country.

Word Hunting Ranch charges $295 a day for hunts. This includes all expenses, with no additional costs. The customer is picked up and returned to the airport, and is provided with licenses, lodging, meals, guides, dogs, and dressing and freezing of the birds taken. Nonhunting guests accompanying hunters are charged $45.00 per day for lodging and meals. Pheasant hunting is the primary activity. However, there is also hunting for mourning dove, sharp-tailed grouse and bob-white quail.

Future plans for the ranch include the addition of quail, chukars and other

game birds so the hunter has a chance to take a wide range of game birds. Initial releases of bob-white have been successful, and the birds are breeding. Within five years, Word hopes to provide some of the finest bird hunting on private land in the nation.

With the improvement of the wildlife habitat and the decrease in cattle grazing and wheat farming, the wild deer herd is expanding. There is an increasing amount of deer hunting and a limited antelope hunt, for which there is a separate fee structure. Two of the bucks that were taken last year came within a few points of qualifying for the Boone and Crockett Club records book.

An additional benefit of the restoration of wildlife habitat, especially in the riverine and bottomland areas, is the provision of habitat for non-game wildlife. Small numbers of prairie chickens have begun to return to the grasslands. Furthermore, the pheasant release program will slowly build up the wild populations and it is likely that some of these birds will spread to adjacent ranches.

Agricultural Biases

Word's most difficult problem has been overcoming the prejudices and attitudes of a traditional rural agricultural community. He has had difficulty in obtaining financial assistance from banks and other organizations that are agriculture-oriented and skeptical about the value of recreation. However, Word reports, "Every farmer around is watching us. They need outside income. They will lose family farms if they can't generate additional income."

Word is confident that his new approach will be successful. The Wildlife Management Institute in Washington, D.C. has commented favorably on Word's switch from cattle ranching to wildlife. The TV program "Fishing with Roland Martin" featured a show on them early in 1985.

Marvis Hogen, South Dakota's agriculture secretary, reported that pay hunting may become increasingly popular with landowners. "We think it's going to be a valuable sideline," Hogen said. "It's the kind of thing that in these tough times I think farmers are going to do." [Word Hunting Ranch, Inc., Box 36, Belvidere, SD 57521]

Resorts, Recreation Developments, Landmark and Natural Site Attractions

This category includes a wide range of land developments: dude ranches, recreational areas and campgrounds, private wilderness areas, private trail systems, private caves and other natural site attractions such as meteor craters, natural bridges, and gorges. What they have in common is widespread attraction and use by substantial numbers of people and hence are fairly densely populated and provide most modern conveniences. Yet their owners strive to maintain the natural surroundings and values that made them attractive in the first place. They are struggling with the same pressures and management challenges as such publicly owned wonders and recreation areas as Yosemite National Park in California, Mammoth Caves in Kentucky, Fire Island National Seashore in New York, or the Gateway and Golden Gate National Recreation Areas in Metropolitan New York and New Jersey and San Francisco, California, respectively.

CASE STUDY: HILTON HEAD ISLAND

Hilton Head Island, one of the largest and most sensitively developed vacation and recreational complexes in the country, is located off the Atlantic Coast of South Carolina, approximately 30 miles north of Savannah, Georgia, and 90 miles south of Charleston, South Carolina. It is one of the largest barrier islands between New Jersey and Florida. It is roughly footshaped, about 12 miles long, five miles at its widest, and is approximately 42 square miles in area.

While over its history it had periods of fairly intensive use as a military site and for agricultural and timber use, it was essentially undeveloped until a bridge connecting it to the mainland was constructed in 1956. It is now one of the more intensively developed and prestigious resort and vacation areas and residential communities in the country. For decades, Hilton Head served as a model for balancing intensive development with environmental preservation. In recent years, however, rapidly accelerating land values and continued growth have brought problems to this paradise. Yet the island remains an example of how to attempt to balance concentrated land use with wise resource protection. Recent problems, rather than negating the original development philosophy, raise important questions that must be dealt with in any debate over how man can live in harmony with the land.

If there are problems now in continuing to control the growth, development, and popularity of Hilton Head Island—as a number of environmentalists maintain—it is partly because the sensitivity in carrying out the original preservation concept and the continued maintenance of the area's beauty and natural resouces have made living there so desirable. Similar problems are confounding the managers of such unique areas of natural beauty and importance as Yellowstone National Park and Yosemite National Park.

Hilton Head is a low-lying island, with its highest elevation being about 25 feet. Wide, gently sloping beaches and dunes vegetated with sea oats, run the length of the oceanside; the interior is forested with a number of pines, including pond pine and long leaf pine, live oaks, water oaks, black gum, sweet gum, bay trees, southern magnolia, American holly, water tupelo, saw palmetto, and contains many swamps and ponds; the sound side is comprised of substantial salt marshes and a network of creeks, sounds and lagoons and wetland areas which interlace the island. The vegetation and climate are subtropical. Some 260 species of birds have been recorded on the island and there are some important rookeries of southern species of wading birds such as egrets, herons and ibis. Alligators, bobcats, white-tailed deer, raccoons, skunks, opposums, and wild turkeys occur throughout the area. There are two important nature preserves and one forest preserve on the island, together with a few smaller ones.

Hilton Head Island was a major prehistoric Indian site. It was "discovered" by the Spanish in 1526 and named for the English Captain William Hilton in 1663. A plantation agricultural system was created by the English in the 1700s, producing indigo, rice and sea island cotton through the mid 1850s. During the Civil War, the Union used it as an army and navy base to blockade southern ports, and development was intensive, with 25,000 troops stationed on the island. It had two newspapers, hotels, a theater and hospital. Following the Civil War, it reverted to a more bucolic life style, largely dominated by freed slaves who engaged in small-scale farming, fishing and hunting. Some

large tracts of land and rice fields were acquired by Northerners as hunting preserves, a pattern that occurred on other southern sea islands. But rapid changes and major development did not come to Hilton Head Island until the bridge to the mainland was completed in 1956.

Island Development

Development has brought great change to the island. There are now at least eight major resort communities, or "plantations," eight major hotels and inns with over 2,000 rooms, plus more than 4,500 rental condominiums, villas and homes. There are over 100 restaurants. There are seven marinas capable of handling up to 100–foot yachts, 20 golf courses, over 200 tennis courts, several dozen swimming pools, 25 miles of paved bicycle paths, four stables for horseback riding, deep-sea fishing, etc. The island's facilities host up to 1,800 meetings and conventions annually, including major golf and tennis tournaments. There are over 1,600 businesses located on the island. In 1984, real estate sales reached $300 million, building permits $200 million, and visitor spending some $220 million.

Hilton Head Island now has a permanent population of about 18,000, with up to 55,000 people resident during the peak summer vacation season. The total number of resort guests annually reaches about 825,000. There are over 5,500 single-family and 11,500 multi-family dwelling units on the island. In order to handle the many problems arising from this dramatic growth, the Town of Hilton Head Island was recently incorporated.

The initial development concept consisted of the creation of large, self-contained resort communities, or "plantations," throughout the island. These were developed as proprietary communities with controlled gates and restricted entrances. Most of the plantations are combination resort/residential communities or all residential areas. The original such development, Sea Pines Plantation, is the largest (5,000 acres) and encompasses most of the southern end of the island. Hilton Head Plantation, the next largest, occupies most of the northwestern end of the island. Other major plantations include Palmetto Dunes, Port Royal, Shipyard, Long Cove, Wexford and Spanish Wells. Approximately 70 percent of the island's land lies within these communities, with the rest consisting of smaller landholdings, resorts, hotels, commercial developments and office complexes. Most of the roads and trails are private and located within the plantations. The only major public road, State Highway 278, runs down the spine of the island.

Sea Pines Plantation

Charles E. Fraser originally owned 40 percent of Hilton Head. It was he who conceived of and drew up a master plan for environmentally sensitive development, beginning with Sea Pines. He had a farsighted vision that carefully controlled development, blending in with the natural environment, would create a premier resort area and insure maintenance of high property values and a prestigious reputation, justifying the initially higher costs of environmental preservation efforts.

His approach was unusual for the late 1950s, which was prior to the era of

environmental concern and governmental regulations controlling barrier island development. Fraser sought the protection of natural areas and used scenic beauty woods, especially cypress, for construction materials. Residential complexes were shielded from roads with buffer zones of trees and other vegetation. There were also strict standards regulating billboards and directional signs that predated the national highway beautification effort.

Throughout the island, the major private builders protected marshes and dunes and their flourishing stands of sea oats. To this day there is a very acute consciousness about protecting the environment and the wildlife.

Sea Pines Forest Preserve

The original covenant for Sea Pines Plantation permanently set aside 1,280 acres (two square miles) of woodlands and open spaces, one-fourth of its total land area. The prime portion of this protected area is the 605–acre Sea Pines Forest Preserve. The Preserve is protected for 99 years and is leased to the State of South Carolina as a wildlife sanctuary, although it is maintained by the property owners association.

The Preserve has some important stands of mature or climax forest which is a dark, subtropical evergreen forest dominated by live oaks, southern magnolias, American hollies, and mockernut hickories. Two major trail systems wind through the Preserve, passing through climax forest, pine stands and a number of boggy areas and swamps, some of which are eighteenth-century rice fields. There are two boardwalks, one crossing a swamp, the other crossing a sawgrass marsh, opening into a hammock of loblolly pines, cabbage palmettos, and red maples. Many of the tall trees are festooned with Spanish moss or entwined with scuppernong grape and yellow jessamine. A former rice field is now a 30-acre waterfowl marsh, attracting wading birds and wintering ducks. There is also a 15-acre fishing pond stocked with bream and large mouth bass. There are many species of birds, alligators up to eight feet long, white-tailed deer, and marsh rabbits. An additional 220 acres are reserved for future nature trails. Self-interpretive nature guides are available, and the Sea Pines security force includes a full-time wildlife officer. The Plantation has over 15 miles of nature trails, biking paths and jogging trails.

Sea Pines and some of the other plantations on the island have protected archaeological and historical sites. Within the forest preserve, there is an Indian Shell Ring, a circular mound of oyster shells, animal bones and pottery fragments, 150 feet in diameter and three feet high, dating back to 1450 B.C. Adjacent to the preserve is a Heritage Farm where old plantation crops of sea island cotton, indigo, sugar cane, tobacco and rice are still cultivated, and windmill pumps and mule-powered cane mills still produce cane syrup.

Audubon-Newhall Nature Preserve

An early conservationist was Caroline Newhall, whose residence on the island predated the bridge. In 1963, she asked Charles Fraser to donate an important 50–acre parcel to the Hilton Head Audubon Society to preserve a unique pocosin habitat. Pocosins are small bogs characteristic of the Carolina coastal lowlands, containing a dominant vegetation of sphagnum moss, sawgrass, maiden cane grass, Virginia chainfern and tupelo gums. The Audubon-Newhall Nature

Preserve was designed as a refuge "to save the native vegetation of Hilton Head Island in an easily accessible area for all to enjoy." Mrs. Newhall works with Sea Pines and other resorts to save rare and endangered plants and wildflowers, and many have been transplanted in her preserve in a favorable environment.

Habitat improvements in the preserve include a pond, which was constructed in 1965, and the clearing of some trees to provide openings for flora and fauna not found in the dense forests. Nature trails were constructed, including a boardwalk overlooking a pocosin. Wildflowers have been planted along the trails and many of them have been labeled. Trail maps and explanatory literature are available for the self-interpretive trail system, guided tours are available on certain days, and volunteers from the Audubon Society maintain the trails and signs and care for the refuge.

In addition to the pocosin habitat, the area protects a transition forest of Florida Scrub, with a unique plant community near the northern edge of its U.S. range with open, sandy woods dominated by three species of pines, especially pond pine and long leaf pine, abundant saw palmetto, common bracken fern and cinnamon fern, and carnivorous pitcher plants. Ms. Newhall says that noteworthy plants include native azaleas and Cherokee beans.

Hilton Head Plantation

Paul Graf of the Hilton Head Plantation, one of the island's largest resort communities and one that continues the strong preservationist ethic, states "As a development that tries to work within the environment, we are about as good as you can find . . . the other plantations here are very good too."

Graf notes that each plantation has a master plan as well as an architectural review board that oversees building codes and tree preservation. Preservation of native trees is such a primary concern that Hilton Head Plantation must get permission from the Town to fell any tree over six inches in diameter, and individuals must get permission from the Plantation in order to develop lots. They have moved lots and even diverted roads to save trees.

Hilton Head Plantation contains some areas which were old tomato fields and had been clear cut. These have been planted with more than 250,000 trees over the past 10 years — mainly pine, and they are scheduled to plant another 35,000 trees in 1985. It has also started a tree farm system where attractive hardwood and ornamental trees, such as dogwoods, are started and then replanted throughout the area.

Another major preservationist effort has been to insure that when golf courses are built, they are designed with a lagoon system to provide drainage, and to see that runoff doesn't harm the adjacent salt marshes and oyster beds.

Whooping Crane Pond Conservancy

The most important refuge is the 137-acre Whooping Crane Pond Conservancy, which is owned and managed by the Property Owners Association of Hilton Head Conservancy. It is considered "a central part of Hilton Head Plantation's 'emerald necklace' of preserved forests and wetlands," and protects vegetation, birds, reptiles and mammals characteristic of the subtropical habitat.

The Conservancy includes a 1,500 foot trail and a 1,086 foot boardwalk, completed in 1975. These are self-interpretive trails with guidebooks and maps, although guided tours are also provided at certain times. The boardwalk crosses through pine forest, boggy bottomland, swamp and sawgrass savanna habitats, and there are a number of observation decks. The most significant area is in the black gum swamp where the boardwalk was constructed through waters up to seven feet deep, and where there is an important rookery for about 250 pairs of colonial-nesting herons, egrets and ibis, which occupy the area between March and October. A gate is used to close the rookery during the crucial spring breeding season to prevent human disturbance. If the herons and egrets are flushed from their nests, predators, such as crows and vultures, often take the eggs and hatchlings. However, blinds are available for nature photographers. The species which regularly nest or occur in the rookery include: cattle egret, snowy egret, great egret, tricolored heron, little blue heron, great blue heron, green-backed heron, glossy ibis, white ibis, wood stork, blackcrowned night-heron, and yellow-crowned night-heron. The swamp's level rises and falls through the seasons and is alternately wet or dry, depending upon the rainfall, and it is also used by wood ducks, mallards, coots and alligators.

The rookery has been diminishing in size over the years in spite of the careful protection it receives. In 1968, the rookery had about 1,000 nests; it now has 250, mainly because there is far less water in the fresh water swamp. The water table of the island has gone down, and as there are no springs, the rookery swamp is completely dependent on rainfall, which has been low in recent years.

Mrs. M. W. MacDonald, who manages the Whooping Crane Pond Conservancy, and other environmentalists point out that the Ocala Aquifer, which underlies the coastal plain, has been dropping noticeably. Industry around Savannah draws its water from the Ocala, in addition to which there is increased use for irrigation and agricultural projects, and for golf courses and developments on the Island.

Cypress Conservancy

The Hilton Head Plantation also has a second refuge, the 50-acre Cypress Conservancy, which contains a pond cypress swamp with a small egret rookery. It has no trails or walks. And a small island in the Sound, Pine Island, has been set aside to be preserved as a nature reserve.

The Port Royal Plantation has a small six-acre arboretum with a significant collection of about 100 native plants which are labeled. It also has the 14-acre Sherman Preserve protecting a historical site of Civil War breastworks and a beautiful forested area. There is also another small rookery located in the Spanish Wells Plantation.

Recent Environmental Concerns

Some members of local environmental groups point out that despite the careful conservation measures, serious problems have arisen. During a recessionary period in the 1970s, some of the plantations got into financial trouble when real estate values went down, and some of them, which came under new ownership, began to move towards more intensive development. In 1980, a suit

brought against the Sea Pines Company argued that there had been discrepancies in the preservation of open spaces. However, the Beauford County Court of Common Pleas and the South Carolina Supreme Court ruled in favor of the Company and the Beauford County Court found that:

> "Sea Pines Plantation Company has now permanently restricted in excess of 1280 acres (two square miles) within Sea Pines Plantation, including the Sea Pines Forest Preserve, to an undeveloped condition, free of homes and any other buildings, and managed in a way designed to preserve the wildlife and the natural beauty of the area, thereby fulfilling its Two-Square Mile Commitment to the plaintiff as restated in the 1974 Property Owners' Agreements and Covenants."

Ed Drane of the Hilton Head Sierra Club argues, however, that Sea Pines should not be able to include golf courses, drainage ditches, utility rights-of-way, etc., as part of its open space.

Environmentalists are also concerned about the quality of the waters and marine life in the salt marshes and sound, as this is one of the last major unpolluted marine environments on the East Coast. Drane maintains that major problems have arisen, especially from sewage treatment, water runoff, and depletion of ground water supplies. As marsh front property has increased in value, developers have built too close to the marshes, causing pollution from non-point runoff. He noted that this has caused some oyster beds to be closed and the Carolina Coastal Council to step in. The growing popularity of marinas is adversely affecting wetlands. And fresh water supplies are being depleted as they are pumped up to water the golf courses.

Drane says that even outside of the plantations, the first small developments were also sensitive to the master plan philosophy. When Hardee's fast food restaurant arrived, it adopted a low key design noticeably different from the usual fast-food flash, employing small wooden signs and lots of vegetation. But now things are changing, and first the county, and then the town, adopted sign ordinances. He argues that newer developers have less appreciation for wildlife habitat and water resources. While on the surface things still look pretty, a number of environmental problems are going unattended.

One of the ironies of adhering to the philosophy of development in harmony with the environment is the increased pressure from more and more people who desire to move there. Ed Drane says that land values have quadrupled in 10 years, and a one-acre ocean front lot in a major plantation that sold for $100,000 is now selling for close to $1 million, and that the cheapest houses for sale in a plantation are at least $110,000. He notes that it was far easier 25 years ago, when land values were much lower, to set aside major acreage as open land or preserves, than it is with current land prices. (This is not a unique problem facing only private protection of natural resources. Accelerating land values make governmental preservation ever more difficult, and the millions of visitors to the National Parks are causing problems with water pollution and the protection of wild plants and animals.)

But even the critics who wish that the growth would stop, and who point out that intensive development is adversely affecting wildlife habitat and water resources, still recognize the noteworthy achievements of the development plan of the plantations. Ed Drane stresses that Charles Fraser was responsible for

the conservationist philosophy of the early plantations and should be given credit. The concept originated with him and it was risky, and whether done for economic or environmental reasons, he foresaw, and others learned, that protecting the environment can be a profitable investment. Caroline Newhall also praises the vision and early work of Fraser, especially his decision to put aside a substantial amount of land for every acre developed.

Conservationists are somewhat heartened by the fact that the Ginn Corporation recently acquired the Sea Pines Plantation as well as the Hilton Head Company, which owned the Port Royal, Shipyard, Wexford, Spanish Wells and Indigo Run Plantations. Ginn is now the largest landowner, holding over 25 percent of the Island, and the environmental community hopes that the reputed strong conservationist ethic of the new owners will help continue the preservationist tradition. They are carefully watching Ginn's new construction project on the beach front.

From almost all accounts, the development philosophy initiated and practiced at Hilton Head Island has proven to be an outstanding model of how to create a major resort and residential community on an environmentally sensitive barrier island. At least within the plantations covering most of the island, the concept of development in harmony with the environment appears to have balanced intensive development and human use not only with scenic beauty, but also with protection and preservation of wildlife, important habitat, native vegetation, wetlands, dunes and other natural resources.

While some people see looming resource problems, and decry the area's growing popularity and continued growth, it is clearly a notable achievement when compared to a great many seaside resorts where clearing, leveling and draining precede development, and ornamental trees are added later. Hilton Head still remains heavily forested. The success of this major resort area is a testimony to the fact that development and environmental preservation can be compatible even on a large scale. Richard Dey, Executive Vice President of the Hilton Head Island Chamber of Commerce, probably echoes the sentiments of most of the residents when he says, "We have some problems, but you only have to go away for a week or two and then return to appreciate the achievements that have been made here." [Hilton Head Island Chamber of Commerce, P.O. Box 5647, Hilton Head Island, SC 29938]

Private Farmland and Non-Industrial Forestland

The vast extent of the nation's private farmlands and timberlands, and their widespread and often small parcel ownership distribution, makes them extemely difficult to inventory and evaluate. Because so many of these lands are owned by reticent, publicity-shunning individuals and families, it is difficult to learn what contributions their owners are making to the conservation of natural resources and environmental amenities. Yet because of the sheer size of these lands, it is obvious that they are providing habitat and wildlife protection even if the landowners are making no special efforts to maintain these resources. Some 421 million acres of farmlands are in cultivation in the United States. By comparison, all federally owned land outside Alaska totals 404 million acres. In the South alone, 73 percent of the forestland is owned by private individuals,

totaling some 133 million acres. By comparison, industry owns 38 million acres of the southern forest, and public agencies own 18 million acres.

Clearly, the potential for significant private contributions in the area of natural resource conservation activities is enormous. With respect to farmlands, much of the advice and incentives for the protection of the land, habitat and wildlife comes from government agencies, such as the Soil Conservation Service, agricultural extension programs, and state fish and game agencies. Hunting and fishing opportunities for landowners, as well as the possibility for fee-hunting on these lands, also encourages the maintenance of wildlife habitat and wildlife.

For the management of private nonindustrial forestlands, organizations such as the American Forestry Association provide information on enlightened private management practices in order to balance forest productivity with environmental and wildlife protection. Specialized wildlife conservation groups also provide management information for the protection and enhancement of populations of certain species of game and nongame wildlife; among them are The National Wild Turkey Federation, Quail Unlimited, The Ruffed Grouse Society, Pheasants Unlimited, Inc., and The North American Bluebird Society.

CASE STUDY: C. JAMES WALLENDAL FARM

C. James Wallendal owns and operates a 250–acre family farm four miles north of Horicon National Wildlife Refuge in Fond du Lac County in southeastern Wisconsin, where there has been a drastic loss of wetlands over the years. As a farmer and conservationist, he has developed a model, award-winning program of combining cash crop farming and the preservation of wildlife habitat and wildlife. Most of the farm is now devoted to the production of sweet peas, winter wheat, and some sweet corn. However, the protection of wildlife habitat and wetlands has been an ongoing project for him. Over the past 30 years, he has restored and set aside over 60 acres exclusively for wildlife use without significantly reducing his profitability.

Restoring Wetlands

Wallendal began farming in 1949 and for some years was intensively working his land, mainly in corn and dairy cattle. In 1963, he tiled and ditched acres of wetlands, reclaiming them for cropland to produce corn and oats. But as early as 1953 he began to start wildlife projects, including the construction of five small waterfowl nesting ponds, and over the years he grew concerned about the increasing loss of wetlands and the decline of wildlife, especially duck and pheasant populations.

Wisconsin's original 10 million acres of wetlands is now reduced to 2.5 million acres, and still declining. In addition to serving as vital wildlife habitat, wetlands act as a sponge to absorb river runoff in the spring and maintain a stable flow of water throughout the year. As more wetlands were drained, there was more flooding, water drained rapidly off the land, streams silted up, the water level rose, and stream flows were reduced. Not only did the reclaimed lands often become waterlogged but, as more wetlands were drained for crop production, there was overproduction of many crops.

In spite of the many problems arising from wetland drainage, increasing

property taxes led to more drainage. A decade or so ago, marginal wetlands were taxed at about $4 per acre and workable land at about $10 per acre. As this increased to about $10 and $22 respectively, fewer farmers feel they can afford to leave marginal wetlands as "unproductive" and thus reclaim them, hoping to produce some income from crops. Waterfowl habitat creation and wetland protection consequently became a major concern.

In the early 1960s, Wallendal entered the soil conservation farm program and began strip-cropping and terracing. He also created a four-acre pond and put up wood duck nest boxes. He fenced off marshland from his pastureland to keep livestock out and eventually got out of the dairy business. By 1981, he began a systematic program of restoring the "borrowed" wetlands from cropland back to productive wetlands and wildlife habitat. His pond system lies along a natural water course connecting a spring to the Rock River, and he constructed a system of dikes and pipes connecting the ponds to control water levels and to maximize vegetation growth for food and nesting cover. He also planted vegetation around the waterfowl ponds for food and cover and planted acres of fertile soils in switchgrass to provide nesting habitat for ducks. He has now restored all of his reclaimed cropland to natural wetlands—a total of 60 acres—and entered them under the federal waterbank program.

The wetland restoration program has been a notable success. Four species of ducks nest there: mallard, green-winged teal, blue-winged teal, and wood duck. Hundreds of ducks feed there during spring and fall migration, as do flocks of Canadian geese and some whistling swans. Local hunters refer to his farm as the "Little Horicon." Herons, egrets, and sandhill cranes visit the wetlands. Muskrats abound; he has trapped up to 75 in a season. There are mink and even a pair of river otter.

Wildlife Habitat

Wallendal also continued to improve other areas of his farm and he created many acres of wildlife habitat. In 1960, he began planting multiflora rose along fence lines, turning them into hedgerows and creating "wildlife travel lanes" and nesting habitat, cover, and food for pheasants, grouse, and songbirds. He expanded and improved a four-acre coniferous plantation woodlot by planting ash trees so there would be berries for birds. Nut trees were planted and, together with the pines, provided both cover and food for deer and squirrels. Adjacent to the wetlands he started a 1,000 tree plantation of the highly valuable black walnut, of which he says, ". . . years from now those trees could put some of my six grandchildren through college."

By 1981, Wallendal phased out cattle pasturing and field corn farming and switched to sweet peas, winter wheat, and sweet corn. This improved the quality of his land and wildlife habitat while significantly reducing his use of agricultural chemicals and top soil loss through erosion. The winter wheat did not need chemicals and the peas did not require pesticides, which he believed were killing off earthworms and thereby reducing the quality and friability of his soils. The Rock River used to have trout that may have been killed by pesticide runoff, as well as by siltation from the severe erosion from his cornfields. The erosion is now also greatly reduced. Winter wheat is a no-till crop, and throughout the farm Wallendal uses minimum tillage practices as well as a two-year crop

rotation to reduce erosion, and has not plowed some of his fields for six years. Highly erodible ground is planted in alfalfa; the river has been rip-rapped to control erosion and to improve the flow.

Wallendal was also concerned about the decline of the ring-necked pheasant population in Wisconsin as a result of habitat loss and has consequently managed the farm to improve pheasant habitat. Substantial acreage of fertile soil has been planted in switchgrass to provide winter cover and spring nesting sites. Some grain and corn is left in the fields for food, and future plans include planting some acreage in black sorghum for pheasant food. In the fields, hedgerows, and woodlots, Wallendal's wildlife habitat projects have been very successful. The deer have returned; there are abundant squirrels, racoons, and rabbits; the pheasant population is thriving; and there are gray partridges.

Governmental Programs

Over the years, Wallendal has received advice and assistance from a number of government agencies, including the Wisconsin Department of Natural Resources, the Soil Conservation Service, the Agricultural Stabilization and Conservation Service (which pays up to 75 percent of some project expenses), and most recently the federal waterbank program, a 10-year program aimed at restoring wetlands in parts of the country where they have been drained for agricultural use. The State of Wisconsin has also developed a pilot program to increase farm habitat for pheasants and ducks, making payments for the land converted to wildlife use.

Wallendal's efforts to restore and create wildlife habitat have not been without substantial costs. Planting nesting cover such as switchgrass costs him about $40 per acre to seed some 15 acres, not including labor and time. The total cost of developing the wetland habitat was about $6,000, mainly in constructing the ponds and the water control system. Also, his crop production has been reduced.

But there have also been significant gains. All told, some 60 acres have been taken out of reclaimed cropland and converted back to wetlands and wildlife habitat, additional acres have been set aside as wildlife habitat elsewhere on the farm, and the wildlife has returned—some in abundance. He created a private wildlife refuge and preserved environmental amenities for the public, both major accomplishments for a concerned conservationist. Wallendal personally likes to hunt and fish, and he derives some income from trapping the thriving muskrat population. He also leases hunting rights to duck and goose hunters.

The 60 acres of wetland habitat entered in the federal waterbank protection program bring him $1,200 annually, which pays the property taxes on these lands. Much of the 60 acres that he restored was prime farm land. The *Wisconsin State Journal* reported Wallendal as saying, "Only about 10 to 20 acres of that was marginal cropland, what I called 'gamble' land. When it was dry I had a crop, but when it was wet I didn't get much."

In addition to the conservation efforts on his own land, Wallendal has been actively involved in wildlife conservation throughout Wisconsin. He is, or has been, a member of the Wisconsin Conservation Congress, the Wisconsin Wildlife Federation, the Waupun Conservation Club, and Ducks Unlimited,

helping to start two DU chapters. He was also a founder and remains an active member of Wings Over Wisconsin, a DU-type organization that works to improve and restore pheasant habitat throughout the state.

Wallendal says that much of his motivation is his desire to preserve a natural heritage for his children and grandchildren. He says "I am probably an exception rather than an average landowner farmer in wildlife and environmental issues, but they are my love. That is the best explanation I can give as to why I did all these things and will continue to do [so]."

In 1983, Wallendal received the annual Wisconsin Wildlife Habitat Award of the Wisconsin Land Conservation Association and was cited as ". . . a role model for all Wisconsin farmers. He is living proof that wildlife habitat can be extensively developed without significant adverse effects on farm profitability." He also received a certificate from the Wisconsin Department of Natural Resources. His combination of farming and wildlife conservation has been reported widely in state newspapers. And the Wildlife Management Institute in Washington, D.C. stated: ". . . if every owner followed Mr. Wallendal's example, the nation's wildlife and associated recreation would have a brighter future indeed." [C. James Wallendal Farm, R2, Waupun, WI 53963]

Specialized Wildlife and Habitat Protection, Restoration and Management Organizations

There is an extremely wide range of highly specialized groups, programs and individual efforts to restore and maintain habitat for diverse species of wildlife. Many of these nonprofit organizations conduct significant and intensive programs to protect and restore wildlife, including endangered species and their habitat. Many of them are actively involved in public education to promote their goals, and their activities often complement, and sometimes surpass, the work of such government agencies as the U.S. Fish and Wildlife Service. As this is done at private expense, it makes an important contribution to the provision of public amenities.

CASE STUDY: SASSAPAW RESEARCH REFUGE

The Sassapaw Research Refuge is an 18-acre farm now devoted to studies of Lepidoptera (butterflies and moths) and the Ichneumon parasitoids (wasps), and to the protection, propagation and restoration of selected species of butterflies and moths. It is a nonprofit operation.

Robert T. Mitchell, a retired U.S. Fish and Wildlife Service biologist and the co-author of *A Golden Guide: Butterflies and Moths*, and his family in 1970 purchased an 18-acre farm on rolling land in southeastern Anne Arundel County, Maryland, overlooking the Chesapeake Bay, 16 miles south of Annapolis and 22 miles southeast of Washington, D.C. As a professional biologist, he had long had an interest in and concern for butterflies and moths, many of which have undergone a long-term population decline for a number of reasons. One major cause is likely the decline and loss of butterfly habitat resulting from human population growth and development, as well as modern intensive agricultural and farming practices. It is also thought that the use of agricultural chemicals and insecticides has adversely affected populations.

Declining Populations

Mitchell notes that butterfly populations have suffered as a result of many modern land-use practices, including the construction of impoundments over productive river bottoms and marshes, the drainage of wetlands for land reclamation, the removal of thickets and a decrease in the number of woodlots. He notes that the hayfields and pastures which formerly were common across the countryside have been increasingly replaced with shopping centers and asphalted parking lots. The increased number of interstate highways and the improvement and widening of country roads, and in particular the use of chemical and mechanical treatments along roadsides, have taken away much habitat and extracted a heavy toll on many butterflies and supportive weeds. Modern street and parking lot lighting systems and floodlights at shopping centers and at interstate highway interchanges also have an adverse impact on moths.

Mitchell also points out that country life-styles have changed radically since his youth. The many small family farms have given way to housing subdevelopments and larger, more intensively managed farms. Originally, each farm often had a spring that fed a little brook that would be lined with thistles and other weeds which supported populations of many butterflies. The cows and horses just ate around the thistles. And people weren't worried about what was eating the leaves on their trees. If people didn't like the dandelions in their lawns, they simply dug them out. Now people treat their lawns and fields with herbicides to remove dandelions, thistles, and even clover — which is not only not a weed, but is especially important for a number of butterflies.

Most Lepidoptera are highly selective in the food plants and flowering plants that they require at the various stages of their life cycles. In 1970, Mitchell began to manage the farm to develop optimal butterfly and moth habitat. It is no longer solely a working farm. He began a program of introducing plants that would attract and feed a wide range of species. He also began an intensive program of management and manipulation of the various major habitat areas on the farm, which included woodlands, wood margins, open fields, hedgerows, and a special area devoted to food crops for monarch butterflies. Various areas of a four-acre pasture are "bush-hogged" during June, July and August to produce fresh sprouts and vegetation in three stages of development in order to diversify the habitat. Japanese honeysuckle, which takes over woods margins, strangles trees, invades open woods, and causes preferred plants to die out, is physically removed wherever possible. Other fields are mowed to encourage growth of desired plant species.

Sensitive Farmer

While most of the farm is no longer in production and is instead devoted to maintaining and improving butterfly habitat, Mitchell still likes to be listed as a farmer and complies with the minimum qualification for being a producer—selling at least $50 worth of farm produce. But even where he produces crops, he is especially careful to protect the butterflies. He keeps agricultural chemical applications to a bare minimum, refrains from spraying fruit trees at bloom and, as a result, often produces wormy plums and peaches. And when rotenone is effective, he uses only that as an insecticide.

A small vegetable garden, used mainly for personal consumption, is located near the farmhouse and is surrounded by one-tenth-acre plots of red clover and alfalfa for butterflies and mulch for the garden. Even the farmhouse lawn is planted in white clover, a preferred food for certain butterflies. A small orchard was planted with fruit trees known to be attractive to various species. Various hedgerows have similarly been planted with important trees and bushes, and a one-acre mixed pine forest was planted for species dependent on conifers.

Scientific Studies

Scientific studies were begun at Sassapaw in 1979, when Mitchell started butterfly counts. Ten counts, scheduled according to the successive blossoming periods of key plants, are conducted each year along a one and one-quarter mile route that transects the different habitats of the refuge. The data collected include the total number of each species, their sex, behavior, immature stages, Ichneumon parasites, etc. It is hoped that over a period of years these counts will enable him to measure the effect of the plant introductions, maintenance operations and habitat manipulations.

Some 30 or more species of butterflies and moths have been located on the refuge, and for some of these Mitchell has made specific plantings or habitat alterations. Mitchell has welcomed assistance in developing the Sassapaw Research Refuge and has offered to cooperate with anyone wanting to use it for field research studies on Lepidoptera.

Sassapaw is not open to the general public. The farm is 33 miles from his home and Mitchell can't be there at specific times, and because it is not a zoo or a butterfly farm, visitors cannot count on seeing butterflies at specific dates. Instead, from November 1 to May 1, Mitchell takes his farm/refuge with him on slides for lectures to various groups, showing the butterflies and habitat at their optimal times and also demonstrating what one committed person can do to help protect wildlife and habitat.

This example of private stewardship by Robert Mitchell is a labor of training, love and concern. There is no money in it. It is used as the basis of his ongoing research into Lepidoptera and provides material for his publications and lectures. He publishes his work and the findings of his studies as scientific papers and delivers lectures, talks and slide shows. He is able to deduct some of the expenses of the operation from his taxes, taking full advantage of charitable deductions, work-related expenses, etc., and this helps make his conservation work possible.

Creating "Backyard" Habitats

There are indications that a small but growing number of people are becoming concerned about the loss of butterflies and their habitat, and especially about the extensive application of agricultural chemicals and herbicides to country fields and suburban lawns in an attempt to maintain perfect, weed-free lawns, and to produce perfect fruits and vegetables. They believe we may be paying a high toll in the loss of beneficial insects, especially pollinators such as bees, butterflies, moths, and birds. There has, consequently, been a growing movement to return to natural gardens and lawns and to encourage the

planting of lawns in native wild flowers rather than persist in attempting, often in vain, to maintain perfect green lawns. However, this runs counter to many county and town ordinances which require that landowners eliminate "noxious" flowering weeds and plants and keep their "artificial" lawns mown and weed free. Also, many housing developments have covenants requiring the homeowners to "maintain" their lawns.

Organizations such as The Xerces Society try to counter some of these mandates by promoting public understanding of the beneficial role of insects in natural ecosystems and the need for habitat protection for butterflies. The Lepidopterists' Society also plays an important conservation role. Beginning in the mid-1970s, there have been an increasing number of popular and scientific articles published on creating butterfly habitat and butterfly gardening. Some people have started butterfly farms for propagation, usually to sell the butterflies to collectors, which may reduce the collection of highly-desired wild butterflies.

At least two national wildlife conservation organizations, the National Wildlife Federation and the National Institute for Urban Wildlife, have developed programs for the restoration of natural habitat areas to the urban and suburban landscape, aimed at reversing the shrinking of wildlife habitat.

The National Wildlife Federation is the nation's largest conservation organization. Through the Federation's Backyard Wildlife Habitat Program, homeowners can apply for certified membership in the program. They must pay a $5.00 application fee, fill out a form with a plan for providing food, water, cover and reproduction areas, and if approved, they are certified and receive a certificate of membership. The Program already has some 3,300 members. While devoted to the provision of habitat for a range of wildlife species, the Federation has specific information on butterfly gardening in its "Gardening With Wildlife Kit." The Federation is hoping to capitalize on the U.S. Fish and Wildlife Service findings which show that 60 million Americans observe, photograph and feed wildlife within a mile of their homes and that 12 million maintain plants to attract and feed wildlife.

The National Institute for Urban Wildlife is dedicated to the conservation of wildlife for the benefit of people in cities, suburbs, and developing areas. It is especially interested in preserving and creating wildlife habitat in heavily-populated locales and conducts research and publishes studies on how various wildlife species are adapting to urban environments, as well as on how to improve and create wildlife habitat in urban areas. Their studies have demonstrated the significance of artificial man-created habitats as permanent wildlife habitat. For instance, storm water detention/retention basins create vital wetland habitat within urban and suburban settings. The Institute has retained Robert Mitchell to prepare a booklet on "Butterflies in Your Backyard." Many garden clubs have also begun to provide information on plantings that will specifically attract butterflies.

Mitchell says that some people might consider him eccentric because of his attitudes and beliefs. But he notes that he's not opposed to progress and it is not just a growth in human population that is threatening the survival of many butterflies and moths; more importantly, the threat stems from a change in people's attitudes. He notes that increasingly people have been conditioned to be intolerant of inconveniences and nuisances and to demand perfection

at the marketplace. They demand and expect perfect weed-free lawns and perfect blemish-free produce. He says that personally, "I feel safer eating the wormy apple and am better off." Through his example and efforts, and that of an increasing number of others who are willing to tolerate some loss to caterpillars and some weeds in their lawns, and who are willing to make space for wildlife habitat, we may continue to have fields and meadows alive with a summer spectacle of butterflies and brightly-colored flowering plants. [Sassapaw Research Refuge, c/o 4109 Tenneyson Road, Hyattsville, MD 20782]

CASE STUDY: THE NATIONAL WILD TURKEY FEDERATION, INC.

The National Wild Turkey Federation (NWTF) was established in 1973 as a nonprofit organization dedicated to the wise conservation and management of the American wild turkey. It is a membership, education-oriented organization with about 28,000 members. Annual dues begin at $15.00. There are over 200 state and local affiliate chapters, and $2.00 of each $15 membership is rebated to the 34 state chapters for local projects. The current budget is about $1,200,000. Additional funding comes from member contributions and a regular program of national and chapter fund-raising dinners, auctions and art sales, and the sale of special guns, knives, caps, etc. Substantial revenue is also derived from the sale of annual wild turkey stamps and prints. (The NWTF is beginning a "grand slam" series of stamps and prints featuring the five subspecies of wild turkey native to the U.S. Many people who are not turkey hunters are avid collectors of the stamps and art work, bringing NWTF financial supporters to about 35,000 members.) The typical Federation member is male, about 40 years old and earns $30–40,000 per year, ranging from blue-collar workers to corporate executives. In states such as New York and Pennsylvania, perhaps 25 percent of the members are blue-collar hunters.

The NWTF works cooperatively with state fish and game agencies and corporate and private landowners to do whatever is needed to assist wild turkey management and habitat management. It works with a technical committee composed of 63 wild turkey biologists representing all states except Alaska to provide state agencies with conservation management information, research data on such subjects as response to hunting, restocking techniques, and the use of transmitters. NWTF has a grant-in-aid program to allocate money for necessary research. A major program provides state agencies with transport boxes to use in translocation of turkeys. These are donated by forest products companies and distributed free of charge by the NWTF to the state agencies. Over 2,500 were distributed within the last year.

The NWTF is also able to speak out on environmental and legislative issues which state or federal agencies may not be able to do. Their overall mission is to fill whatever gaps they can in protecting and preserving wild turkey habitat throughout the country.

Educational Mission

Primarily an education, research and funding operation, the NWTF does not have the staff or resources to proselytize actively for the enhancement of turkey habitat on corporate and private lands. However, it does participate in

the National Wild Turkey Symposium held every five years which is attended by many private landowners. In addition, at various one- to three-day chapter conferences and programs around the country, the NWTF will work with local landowners who want assistance in managing habitat for turkeys, providing advice after visiting habitat. The NWTF also participates in various meetings held by state game agencies. Over the last three years, the NWTF director of research and management has visited 25 states to look at habitat. The organization also reprinted a South Carolina state game management publication, "Game on Your Lands," for private and corporate landowners wanting to know how to manage lands for the eastern wild turkey.

While there is relatively little direct corporate involvement in NWTF's funding, forest products companies donate the turkey transport boxes, cooperate in research projects on corporate timber lands, and a national firm donated land for the Wild Turkey Center in Edgefield, South Carolina. Austin, Nichols Distilling Co., distillers of Wild Turkey Bourbon, is an NWTF supporter and donated to the construction of the center.

The NWTF publishes a bimonthly magazine, *Turkey Call*, for its members, along with various newsletters and other printed material distributed through the membership and to various news media.

Wild Turkey Recovery Efforts

While no one knows the size of the original wild turkey population in America, it played a notable role in the Colonial period as a source of food from the first Thanksgiving at Plymouth Colony on, and was proposed as the national bird by Benjamin Franklin. However, overhunting and loss of habitat soon greatly reduced turkey populations. By 1930, it is estimated that there were no more than 30,000 wild turkeys in the United States. The eastern population was reduced to remnant flocks in inaccessible bottomlands and mountain areas and the smaller western populations seem to have survived through the absence of human pressure.

Through the end of World War II, wild turkey populations remained at an all-time low. Initial efforts into the early 1950s to restore populations by releasing penraised and more or less domesticated turkeys back into their historic ranges produced futile and discouraging results. The outlook for wild turkeys was not favorable. But in the mid and late 1950s, various state game agencies began to trap wild birds in their remaining refugia and transferred or relocated them to unpopulated prime habitat and slowly, populations began to recover.

These efforts have led to "a modern conservation marvel." There are now over two million turkeys nationwide in every state except Alaska, including all of the major Hawaiian Islands. Even states with marginal habitat, such as Nevada and Utah, have populations, and they are recovering especially well in densely populated states such as New Jersey and Connecticut. The wild turkey has proven to be very hardy, wily and adaptable. In spite of major habitat conversion, even such major farming states as Iowa now support thriving populations where small woodlots surrounded by corn plots support up to 80 turkeys per section—among the highest densities in the country. Throughout the country, populations have recovered to the point where over 44 states now have a turkey hunting season, expected to increase to 46 states within a year. Hunting expenditures, including

licenses and permits and taxes derived from the sale of equipment, are producing revenue for state game management agencies. States such as Missouri, with thriving populations, are now actively swapping turkeys with states like Michigan for other wildlife they hope to reintroduce in suitable habitat.

The National Wild Turkey Federation has played a substantial role in the successful recovery program for this species throughout the country. The NWTF recently created a NWTF Research Foundation with its own trustees, headed by former astronaut Wally Schira, to raise corporate funds for the sole purpose of conducting basic research on wild turkeys. [The National Wild Turkey Federation, Inc., Wild Turkey Center, P.O. Box 530, Edgefield, SC 29824]

Associations, Alliances, Coalitions and Technical Service Organizations

A number of regional and nationwide associations and alliances have been formed in recent years to assist individual property owners—wildlife conservationists, farmers and ranchers, sportsmen, individual land trusts, and others—in protecting habitat, wildlife, natural areas and open lands. To a large degree these are service organizations which assist their members with a wide range of information, advice and services. They provide technical and biological expertise on management issues. They advise on legal matters, environmental legislation, protection from trespass and liability problems. They sometimes provide discount insurance and information on advertising, marketing and tax problems. They conduct membership surveys and publish directories and inventories of their membership, and publish newsletters, magazines, journals and books relevant to the needs of their members. Many of them host annual meetings to bring together experts in the field, government officials, and the membership. Increasingly, some of these organizations assist their members in lobbying for tax incentives and various benefits.

CASE STUDY: OPERATION STRONGHOLD

Operation Stronghold is "A nationwide, nonprofit corporation dedicated to improving wildlife habitat and conservation practices on private land." It was established in 1979 to create a nationwide coalition of private landowners pledged to wildlife conservation.

Its president, Dayton Hyde, is a 60-year-old rancher, conservationist, photographer, author of a number of wildlife books, lecturer, and former board member of the Defenders of Wildlife. Hyde lives on a 6,000-acre ranch in a forested mountain valley in Klamath County in southern Oregon, owns another 6,000 acres of ranchland, and runs 1,500 head of cattle.

Hyde had grown concerned about a number of disturbing trends he saw affecting wildlife and private lands. He pointed out that during the 1930s there was a cooperative spirit between government and private landowners to create wildlife conservation programs on private lands including shelterbelt plantings, wildlife food and cover plots, restoration of wetlands, waterfowl breeding ponds, etc. However, in recent decades this cooperation had largely ended through a combination of population growth, land scarcity, changing economic conditions,

and "short-sighted tax laws [which] broke up family agricultural units and forced either subdivision or intensive cultivation."

Hyde also notes that: "Many remaining landowners who harbored wildlife or built ponds and wetlands discovered that they had created a managerial nuisance. The public flocked to the land, often destroying the very values they came to enjoy. They left gates open, vandalized expensive machinery, scattered garbage, trampled crops, started fires, and even sued for injury. The landowners best protection was a trespass law that was not only ineffective but created ill will. To the landowner it seemed easier to sterilize the land and hope that people would leave him alone."

Hyde believed that these trends were creating an atmosphere in which increasing numbers of ranchers and farmers felt that wildlife resulted in severe nuisance conditions, that maintenance of wildlife habitat led to losses in farm productivity, and that the presence of abundant wildlife, especially rare and endangered species, invited government regulation or even taking of private land.

Conservation Plus Productivity

One of Hyde's first aims was to demonstrate that farmers and ranchers could restore or create wildlife habitat while maintaining and often increasing agricultural productivity. Thus, he set about to improve his own ranch and use it as a model. Starting in the mid-1970s, he took some of his least productive land, a flat sagebrush area, and by bulldozing a basin and damming a canyon, he used snow melt to create a 60-foot deep lake with a three and one-half mile shoreline. Hyde Lake now provides habitat for up to 5,000 waterfowl, a pair of bald eagles, ospreys, two pairs of sandhill cranes, a family of trumpeter swans, and many other species. Wildlife from the nearby Fremont National Forest come down to use the lake. Trout weighing up to 12 pounds now thrive there. He believes this demonstrates that even the most marginal land can be used to create "a wildlife paradise."

Hyde also restored about 25 percent of his pasture lands back to wetlands, which had earlier been drained to create hay fields. The combined wetlands and lake improved the productivity of his farm in a number of ways: it modified the climate by providing warmer irrigation water and decreasing frost damage to crops; it increased grass production and attracted birds that help control grasshopper damage. Hyde claims that these improvements to his ecosystem have increased his beef production by 50 percent.

Hyde has also tried to work with coyotes instead of against them. While this is a controversial idea in livestock country, he has long followed a policy of dragging cattle carcasses into the woods to serve as coyote food, and he believes that this, together with the rodents attracted by his wetlands, keep the coyotes well fed, because he hasn't lost a calf in years. He believes that he and others have demonstrated that wildlife and wildlife habitat are compatible with profitable ranch management. The presence of wildlife doesn't mean loss of crops or livestock; wildlife and agriculture can work together.

Hyde's guiding philosophy is: "Man does not have dominion over the land but rather responsibility to it." He objects to the idea that man and wildlife cannot coexist, because he recognizes that some of the most productive private

land that was homesteaded, especially in the West, once supported major wildlife populations.

As a conservationist, Hyde has been concerned about the loss of wildlife and wildlife habitat on private lands, particularly because of their critical importance. He maintains that some "eighty percent of wildlife food, in the form of insects, weed seeds or crop residues, is on private land," but that as adjacent wetlands and wildlife cover disappear, these important assets cannot be utilized. "Nor can we rely on public lands to maintain species diversity. However scenic or spectacular, most National Forest, BLM, and state lands lack food and water to sustain large, varied wildlife populations except on a limited seasonal basis." Yet farmers and ranchers are expected to provide wildlife and maintain habitat essentially at their own expense, and are criticized for not doing more. This increasingly strains relationships. He writes: "Private land . . . carries the richest potential for wild plants and animals. Clearly, these tracts cannot be taken out of production for strictly wildlife purposes. Fortunately, such lands can provide habitat without cutting crop production, providing the nation with the most effective wildlife management system it has ever had, and at little cost."

Private Initiative on Private Property

As a rancher and landowner, Hyde has also been concerned about the growing hostility to private ownership. Ranchers have been receiving bad publicity because of harmful grazing practices on public lands and the public perception is that ranchers and farmers threaten wildlife habitat. This is creating a blanket condemnation of private land ownership. He also fears that if wildlife and habitat continue to decrease, there will be increasing pressure for governmental agencies to acquire private lands and as more land is posted, animosity between the public and private landowners is growing. Hyde says, "Private land ownership as we know it is in trouble. . . . We have to prove that private land can indeed serve a function not served by public lands."

To resolve some of these difficult problems, Hyde decided "the time seems exactly right for a simple, workable program led by the private sector—ranchers, farmers, timber producers—to create vital reservoirs of wildlife or plants on their own lands." Operation Stronghold was set up as a voluntary coalition of rural landowners, privately financed by membership dues and grants, and directed by the landowners themselves. The Operation Stronghold brochure points out that the landowner retains control over his land. "In no way does it affect one's deeded rights, ownership or title. The landowner himself is in charge. He can allow public access or deny it as he sees fit. He can drop the program at any time. . . ."

The concept was to create "a network of private wildlife strongholds—tracts of private land on which *significant* wildlife and conservation programs are carried out by landowners in return for varied benefits." The idea was to create a tradeoff, by obtaining voluntary commitments from landowners to create and improve wildlife habitat and protect wildlife in return for a package of benefits provided by the organization. These benefits would include the promotion of public understanding of and appreciation for private property, the need for providing undisturbed wildlife habitat, increasing public appreciation of

landowners' contributions to the provision of environmental amenities, and to help landowners protect their property and investments.

Membership dues are $20 a year. Operation Stronghold provides technical assistance and ideas to landowners, and helps them identify areas where wildlife habitat can exist without adversely affecting agricultural production. Other activities include providing liability insurance to the members and exerting political pressure toward the creation of innovative programs at the state and national level to obtain greater legal protection against trespass and to obtain some form of tax incentives for those qualifying for the program.

A crucial part of Stronghold's program involves the definition and acceptance of *"significant"* contributions to wildlife habitat and conservation. Among the criteria suggested are: planting shelterbelts, planting wildlife cover and food plants, creating or restoring wetlands, restoring fisheries, fencing fragile stream banks, creating forest edge habitat, protecting endangered plants, patches of native prairies, and areas of unique natural diversity, and providing winter food for wildlife. Not only are potential members' lands evaluated "on the basis of their real or potential contribution to the program" but their continued qualification for the program is "evaluated on an annual basis."

Trespass Enforcement

One of the key aims of Stronghold was to begin to resolve the vexing problem of trespass. Not only does much of the public react negatively to the traditional posting of signs reading "Private Property; No Trespassing; Keep Out," but the judicial system has seldom enforced trespassing laws with much enthusiasm. Hyde devised an innovative, large, bright yellow, triangular sign, made of corrugated styrofoam which has proved to be very effective. First, it avoids the "Keep Out" syndrome. It reads: "Member, Private Land, WILDLIFE STRONGHOLD, a Nationwide Project. This landowner cares: He has committed his property to a significant conservation and wildlife program benefitting YOU. Wildlife needs privacy. Please cooperate. It is unlawful to enter these premises without written, dated permission of the landowner." The margins are illustrated with five species of wildlife. The public seems to respect the concept and the signs, resulting in less vandalism and trespassing. He had previously lost 50 to 100 normal "No Trespassing" signs each year, but has yet to have one of the new "Wildlife Stronghold" signs torn down. Furthermore, a certain element of the public appears to delight in shooting at "No Trespassing" signs, and a single shot usually does considerable damage to the normal metal signs. However, a bullet passes cleanly through these styrofoam signs with little noticeable damage and apparently reduces the pleasure of "sign potting." Also, through concerted educational efforts, judges around the country are increasingly coming to recognize the significance of the Stronghold concept and are beginning to come down harder on trespassers entering members' lands. Operation Stronghold provides the signs at cost—$3.00.

Expanding Network

Considering its very recent start, Operation Stronghold appears to be catching on by providing a necessary service to landowners. There are now over 400

members around the country who have pledged some three million acres to the program. Two hundred and fifty thousand acres are located within Klamath County, where Operation Stronghold has been widely publicized. However, members are located in all the states and have even joined from England and South Africa. Stories on Operation Stronghold have begun to appear in newspapers, magazines such as *OMNI*, and ABC's "20/20" television program.

Individual members have developed unique programs. An Oklahoma rancher who was plagued by rodents erected nest boxes for American kestrels (sparrow hawks) which began to help control the rodent population. A Michigan hay rancher who reported that bobolinks, an attractive field-nesting song bird, had disappeared from her part of the state, was advised that harvesting usually coincided with the key nesting period of many field birds. By leaving a rocky area in the center of her fields uncut she successfully attracted nesting bobolinks. Other members are creating wetland and marshes. Wild turkeys are being re-established in Montana.

Hyde views Operation Stronghold as a system of individual Noah's arks, preserving wildlife and habitat. He says that landowners often complain about the cost to an individual ranch that attracts wildlife. If one does it alone, deer and elk may multiply or converge on fields and cause substantial crop losses. However, if neighboring ranchers join together, the wildlife habitat area increases and the herds spread out. The more arks, the better.

Hyde believes that the government can't legislate caring or concerned private behavior, nor can federal money alone create it. But public lands cannot alone guarantee the survival of American wildlife because of the abundance, extent, and natural productivity of private land. But given the correct mix of technical services, incentives and protection, private landowners can and will act voluntarily.

Operation Stronghold concludes: "The Stronghold network helps restore our wildlife, bringing back into wildlife use rich, productive lands the federal government cannot and should not buy, land whose marginal areas can support wildlife without lessening agricultural productivity."

Operation Stronghold appears to be an innovative and successful solution to a major problem, the loss of wildlife and habitat on the nation's major landform, the private farm, ranch and timber land. The program is increasing the wildlife carrying capacity of these rich lands, while maintaining and often improving crop and livestock productivity, decreasing trespass and vandalism problems, and creating a better relationship between private landowners and the public. [Operation Stronghold, Box 234, Chiloquin, OR 97624]

Observations and Analysis

The foregoing studies illustrate a diversity of innovative, important and privately initiated efforts to protect and conserve a part of America's natural heritage, especially its wildlife, wildlife habitat and unique landscapes. Some of these organizations have been active for almost a century. Other programs are new and experimental.

The Trustees of Reservations, among the first major efforts in American history to set aside scenic and historic lands for the benefit of future generations, was

founded in 1891. The Word Hunting Ranch was begun in the early 1980s. All were attempts to solve problems or take advantage of opportunities presented in their time. The Trustees of Reservations, located in one of the first states to face population and development pressures, attempted to save choice and important areas of Massachusetts' natural landscape. The Word Hunting Ranch, C. James Wallendal Farm and Operation Stronghold have taken somewhat different approaches to resolving a more recent but increasingly pressing problem, the loss of wildlife and wildlife habitat on modern, intensively-managed ranches and farms.

These and the other organizations selected for review are located all across the country — in Michigan, Massachusetts, New Mexico, Maine, Pennsylvania, Oregon, South Dakota, South Carolina, Wisconsin, and Maryland. Three of them are nationwide organizations, The Archaeological Conservancy, The National Wild Turkey Federation and Operation Stronghold. Two of them are statewide organizations, the Michigan Audubon Society and The Trustees of Reservations. The others are local, ranging in size from the 2,783,170 acres of North Maine Woods, Inc., to the 18 acres of the Sassapaw Research Refuge in Maryland.

About half are nonprofit organizations: Michigan Audubon Society, The Trustees of Reservations, The Archaeological Conservancy, Hawk Mountain Sanctuary Association, Sassapaw Research Refuge, The National Wild Turkey Federation, and Operation Stronghold; the rest are profit-seeking: North Maine Woods, Sea Lion Caves, Word Hunting Ranch, Hilton Head Island, and the C. James Wallendal Farm.

What They Do: The Public Benefits

Hunting

Hunting and the protection of habitat for waterfowl, other gamebirds and game species has traditionally been one of the major motivations behind wildlife habitat protection and acquisition in America, by governmental and private entities alike. Thus, two of the organizations studied are specifically involved with wildlife hunting. The Word Hunting Ranch was created to derive income mainly from pheasant and deer hunting, and The National Wild Turkey Federation was established to restore wild turkey populations and to conduct research and provide advice on habitat requirements mainly for turkey hunters. Whatever the reason for its protection, however, the existence of the habitat also provides living places for a wealth of non-game species. Hunting and fishing are among the many recreational activities provided by the North Maine Woods, although the primary activity and concern of the landowners is the production of forest products. C. James Wallendal enjoys hunting on his small family farm and also derives some limited income from leasing hunting rights.

Birdwatching

Although hunting has played a major role in the development of a conservation ethic in America, birdwatching, or "birding," has come increasingly to play a very important role. The United States is probably second only to Great

Britain in the percentage of its citizens who engage in birding activities, purchase birdbooks, binoculars and cameras for birding, and provide winter feed for birds, erect birdhouses, and acquire and protect habitat for birds.

The various Audubon societies were pioneers in the protection of wild birds and their habitat, beginning around the turn of the century. The National Audubon Society in particular began an innovative program in 1900 of organizing Christmas Bird Counts where groups of birdwatchers would go afield to count all the species and individuals they could in a 24-hour period in a limited area, now a circle of 15 miles in diameter. This was proposed by the late Frank M. Chapman as an alternative to the then fashionable Anglo-Saxon Christmas activity of a "side hunt," where sportsmen went afield to shoot as many birds as they could. Records have been published by the National Audubon Society since the first count, and well over 1,000 counts are now conducted each Christmas Week, with three dating back to the original 1900 count. This effort has not only helped create the burgeoning sport and activity of birdwatching, counting, and listing, but has also provided invaluable data over the years on bird population trends. For example, these data have helped to detect species declines in time to make detailed studies and devise conservation remedies, and also helped create a nationwide wildlife ethic and an awareness of the need for the protection and preservation of habitat.

Three of the organizations studied were specifically created to protect birdlife and habitat: The Michigan Audubon Society, Hawk Mountain Sanctuary Association, and The National Wild Turkey Federation. Although The National Wild Turkey Federation undertook its activities in order to restore wild turkeys for hunting, it has also played a major role in reestablishing turkey populations throughout the country for hunters and birdwatchers alike. Other organizations have also given special attention to protecting birds and protecting and restoring their habitat, among them Sea Lion Caves and Operation Stronghold. And all of them provide habitat for birdlife.

Open Space and Unique Habitats

Increasingly, private sector organizations have moved into land and habitat preservation for specific, locally significant reasons: to save open areas or open lands; to protect areas which have scenic importance; or to preserve special types of habitat or biological diversity that are either rapidly disappearing or are especially vulnerable to development and conversion to other uses. In particular, these include wetlands, prairie grasslands, certain types of vegetation, and the specialized habitat that a number of non-game and non-avian species are dependent upon, including mammals, reptiles and invertebrates. The Sea Lion Caves has protected a rookery for the Steller sea lions and their sea cave habitat as a profit-seeking tourist attraction, and the owner of the Sassapaw Research Refuge has been managing and converting a small farm into a refuge for the protection, propagation and scientific study of butterflies.

Recreation Development

The resort community on Hilton Head Island is noteworthy as one of the first major post-World War II developments to build within the environment

rather than upon the environment and to demonstrate that the protection of forests, wetlands, beaches, open areas and wildlife could be profitable.

Why They Do Them: Motives and Incentives

The incentives for these private sector resource conservation activities appear to be as varied as the activities and interests which characterize our highly diverse, individualistic and pluralistic society. There is no single incentive which stands out as critical in directing individual or organizational self-interest towards environmentally sensitive behavior. Such activities seem more to demonstrate that when private initiative is given free rein in nearly any area of human endeavor, there will be those who will take innovative steps and actions to put into effect their own plans, programs and visions.

Profit-Seeking Organizations

With regard to the motivations of the profit-seeking organizations considered here, North Maine Woods is instructive in a number of ways. First, the landowners are primarily interested in managing their landholdings for the profitable production of forest products. The relatively recent efforts to manage public access is a result of the increasing demand for the use of these lands by the public for outdoor recreation. The additional costs associated with this increased recreational use of these lands—for policing, maintenance, trash removal, liability—have lead these landowners to seek ways to minimize such costs or offset them with new revenues. In some states, high property taxes are leading landowners to seek ways to offset this kind of cost as well.

Maine land laws define all lakes over 10 acres in size as "great ponds" to which the public has the legal right to cross private unimproved land to gain access to the lakes for recreational use. Maine also has an open door policy, guaranteed by legislation, for public crossing of private forest land for hunting and fishing, and hunters can use any private forest lands unless they are specifically posted against hunting or trespassing. Because of this general provision of free public access to private lands, the landowners in the North Maine Woods area, which abounds with lakes, ponds and rivers, have long experienced public usage of their lands for recreational use. It was only during the 1960s and 1970s, when the growing popularity of outdoor recreational activities by the public began to accelerate, that this became a problem for the landowners. Increased recreational demands, and the associated problems of litter, road decay, visitor safety, and the threat of forest fires necessitated the development of an innovative program of public use management and the present fee system for use of the facilities provided by North Maine Woods.

International Paper Company (IP), which is not only a major landowner within the North Maine Woods, but is also the nation's largest private landowner, with some seven million acres around the country, points out that different state laws affecting land use, and different institutional arrangements, play a very important role in its decisions regarding the management of timber holdings and the incentives for improving habitat and managing it for multiple purposes. This holds true for most companies in the forest products industry.

For example, in the *New England* states of Maine, New Hampshire and

Vermont, which have mandates for public use of private lands, there is little incentive for a private owner to carry out expensive programs of habitat improvement or to manage the resources for the benefit of specific wildlife species because the landowners cannot capture those values. Instead, they will generally engage only in those improvements necessary to safeguard both the visiting public and their own lands and resources.

However, IP notes that in neighboring *New York* state, if private lands surround a lake, private landowners can prevent people from going on it, or they can charge a fee for access. Thus, they have put money into improvements because they can earn a return. For instance, they will tailor timber cuts to benefit particular species and groups of hunters—such as for bear, deer or grouse, because in New York they can lease an area surrounding a lake for the exclusive use of a hunting club.

In the *Southeast*, especially in Georgia, Florida and Alabama, forest products companies have historically managed extensive areas for hunting, either on a fee-hunting basis or leased to private hunting clubs, and many employ sizable staffs of biologists and wildlife managers to improve the habitat. The sporting public seems happy to pay a fee to hunt and hopes the land will continue to be available for that purpose. In these states, where there has been a long tradition of private fee-hunting, the companies engage in cutting practices, controlled burns, the provision of food plots and stream corridor buffer zones, and manage for a wide variety of different wildlife and recreational uses. In fact, IP notes that it, and many other companies, are increasingly committed not only to managing timber, but also other activities that can help return some income or profit to the company.

These arrangements have led to many mutual benefits. The public users are becoming increasingly appreciative of the opportunity to have access to areas for hunting, fishing, trapping, and recreation, and often cooperate willingly with the landowners to minimize abuses. Many report damages or violations to the landowners and suggest improvements that might be made. This willingness to pay for the use of these private lands, as well as a respect for the lands, has motivated landowners to provide more and improved recreational opportunities.

In the *West*, a still different picture exists. Here, the long tradition of free access to vast expanses of public lands, including tens of millions of acres of national forests, has created a milieu in which the public often believes it has a right to free access to *all* lands for hunting, fishing and outdoor recreation. This has caused major problems for private landowners in managing public use—controlling illegal timber cutting, vandalism, and forest fires—as well as in protecting endangered species and wildlife. Furthermore, since the federal government provides substantial outdoor recreational opportunities without charge, there is virtually no incentive for forest products companies in that part of the country to undertake expensive management programs to benefit wildlife or the public, since there is little likelihood that they will realize a return on their investments.

While most private western timber lands are accessible to hunters, fishermen, birders and hikers, this is generally not publicized. Knowledge of these opportunities is often restricted to nearby residents. Some companies simply allow free access, recognizing the difficulty of preventing public access, as well as the

goodwill to be generated from allowing neighbors to use their lands; others are beginning to require use permits to control and manage access; a few are able to charge fees.

But generally, more visitors simply mean more problems, especially in areas where it is difficult to generate revenue from public access. However, it is important to note that some companies do make special exceptions and sometimes even encourage the public to use campsites and visit tree farms in order to take advantage of the opportunity to educate the visiting public on the needs of the forest products industry as well as the public benefits provided at private expense.

The attitudes in the West are similar to those in New England, where the absence of a tradition of fee hunting or lease hunting, combined with a tradition of public access (either to forest lands in the public domain or through laws requiring access to private lands), limit the opportunities for generating revenue. But even in the West, there appears to be a growing awareness and acceptance of public fee hunting on private lands. Many sportsmen already know that some of the best remaining hunting and fishing in the West is now on private lands, where exclusive ownership rights can and do limit the number of users and where there are strong economic incentives to maintain and improve the quality of wildlife and habitat. And increasingly, people are willing to pay for that experience.

One of the concerns of forest products companies throughout the nation, but especially in those regions where they are generally unable to generate revenue from public access to their lands, is that public access creates traditions of use and expectations of continuing use. Yet, all forest products companies must retain the ability to close off entry into particular areas, often without notice, in order to conduct necessary business operations and prevent forest fires.

Forest products are still the foremost activity of this industry; the provision of public uses for profit or goodwill is usually ancillary. However, the example of North Maine Woods, and other evidence of increasing resource management for non-timber uses, illustrate how changes in institutional arrangements, which seem to be the most important determinant, influence these companies' perceptions that there are sufficient economic incentives for them to engage actively in the private provision of environmental amenities for the public.

Not-for-Profit Organizations

The various nonprofit organizations—the traditional conservation and wildlife organizations, the growing number of specialized land trusts, and other associations and service organizations—illustrate the unique strengths and abilities of the nation's independent "third sector," those institutions or individuals that are neither governmental nor commercial, to undertake a wide range of activities and solve a wide range of problems which might be difficult or impossible for either government or the profit-seeking sector to attempt. Often they simply step in voluntarily to accomplish privately, and independently, whatever they feel needs to be done in the area of natural resource and wildife conservation and in the preservation of environmental amenities. One of the most important characteristics of these independent sector activities is that they

are able to proceed quickly and quietly to take action to protect and preserve those natural resources which they believe deserve immediate attention. In many cases these actions precede any general public awareness or concern about a given environmental problem. Thus they are able to undertake activities which governmental agencies are not able to fund through tax revenues, and to begin programs which profit-seeking enterprises are not able to create.

There is also a deep sense of mission and commitment associated with these nonprofit activities. They are characterized by strong voluntary enthusiasm and belief in their cause. Many of these activities, programs and organizations operate mainly with volunteer help. Often, even the officers put in long hours of unpaid work, and some organizations have existed for years with largely unpaid, volunteer workers.

The generally limited finances of many of these organizations and programs has, perhaps surprisingly, led to the creation of what can only be viewed as one of their greatest strengths—the need to improvise. These groups have had to become extremely effective at discovering cost-effective, innovative, creative and imaginative methods of acquiring, managing and protecting natural resources.

One of the major incentives allowing these nonprofit organizations to carry out their missions has been their legal status as tax-exempt charitable organizations. While their tax-exempt status has perhaps not been absolutely crucial for their basic membership support, for which members do receive such things as newsletters, magazines, journals, membership pins, patches or decals, usually free access to the preserves or refuges, as well as a personal sense of doing good, it has certainly been important beyond this initial level.

It has been vital when it has come to the "higher" membership categories that nearly all of these organizations maintain, such as "sustaining," "supporting," "sponsor," and "patron," where dues increase considerably. It has most likely been indispensable when it comes to obtaining major individual contributions, gifts and bequests, and major corporate contributions. It has also been a crucial consideration for gifts of lands, habitat or estates, from both individuals and corporations.

The most significant incentives involve the various charitable tax laws, whereby the United States Tax Code, through a multitude of tax deductions, tax credits, and tax deferrals for individuals, estates and corporations, allows a wide range of charitable contributions including money, gifts, land, and conservation easements to nonprofit conservation organizations. By taking full advantage of the available tax incentives, individuals, estates, and corporations reduce their tax burdens by making charitable contributions to nonprofit conservation organizations, while making significant private contributions to the protection and provision of public environmental amenities.

The nonprofit, charitable conservation organizations argue that although these deductions allow individuals and corporations to shelter income and to reduce their tax burdens, the donor making charitable contributions receives only partial recompense for the value of the contributions. Therefore, the public still benefits by obtaining the conservation or preservation of environmental amenities, wildlife habitat, and open spaces at substantially less than it would cost to purchase them.

It is also important to recognize that along with these positive inducements, there are negative or "perverse" incentives that encourage, often inadvertently,

the conversion, clearing, plowing, ditching, and draining of important and sensitive wildlife habitat such as low-rainfall grasslands, wetlands, bottomland hardwood forests, and other ecologically valuable lands. Ironically, these adverse impacts are frequently induced by government sponsored programs: tax incentives, subsidies, direct payments, or a number of indirect methods.

While some environmental groups are working on behalf of favorable tax treatment of private charitable contributions for conservation purposes, others are promoting legislation that will serve to reduce or eliminate existing "perverse" tax and other economic incentives that lead to the destruction of natural and wildlife habitats.

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These case studies demonstrate that for a wide variety of reasons, many individuals, groups, organizations, corporations, and associations throughout the private sector, both the nonprofit and the profit-seeking portions, are working, often quietly and without seeking publicity, to protect and preserve the natural heritage of our country. This is stewardship and private initiative at its best. It is especially impressive in offering an array of diversity and innovation, in which the talents and genius of a pluralistic society are brought to bear on a widely-shared goal—the protection and conservation of the nation's natural resources and environmental amenities for the use and enjoyment of the present generation and those to come.

The case studies reported in this chapter are taken from a study in preparation under contract with Robert J. Smith, Washington, D.C., entitled *Inventory of Private Sector Natural Resource Conservation Activities*, under an interagency agreement between the President's Council on Environmental Quality and the U.S. Department of Interior. The analysis is solely that of the Council on Environmental Quality.

PART III: CURRENT CEQ ACTIVITIES IN ENVIRONMENTAL POLICY

Chapter 10
Issues in Environmental Science

The nation's goal of ensuring environmental quality is often hampered by the inadequacy of the scientific or quantitative basis necessary to make public policy choices. More specifically, in almost every area of environmental concern, we lack reliable indicators of environmental quality to provide baseline information for decisions and action.

Environmental indicators should provide standards for measuring environmental health so that we can assess situations, monitor on-going programs, and thus be able to evaluate whether efforts are successful. In only one area, air quality, do we have an indicator — the pollutant standards index — based on a widely accepted theory of knowledge.

This is only one of the research and development areas that has been identified as requiring increased attention over the long-term. In 1984 an interagency committee was established by the Council on Environmental Quality to try to distinguish those environmental issues and areas requiring greater emphasis. A panel of experts representing both the public and private sectors identified 14 such areas — several because they are critically important and others because of the large gaps that exist in the knowledge base.

Biotechnology and its implications is one area of increased attention. The ability to create precise alterations in the genetic information of certain cells, thus permitting their growth or function to change, has important applications to modern medicine, agriculture, and industrial uses. The challenge is how to ensure that health, safety and environmental pollution concerns are addressed without stifling technological innovation in this important field. Since biotechnology transcends many environmental fields, there has been a need to review the regulatory requirements applied to commercial biotechnology and to develop a consistent interagency regulatory policy.

Some particular environmental problems still largely remain mysteries as far as determining precise cause-effect relationships and knowing with some degree of certainty what action to take to address the problem. One such area is acid rain, which was previously associated with certain aquatic ecosystems, materials and structures. Now concern has arisen that acid deposition could affect forests and crops and indirectly human health, because of an accumulation of heavy metals in game fish and drinking water. Programs currently underway seek to address the significant uncertainties associated with the process and with the consequences of acid deposition. An expanded and accelerated research program is attempting to reduce the scientific uncertainty; with this as a base, a strategy can then be devised to deal with the acid rain problem.

As indicated earlier, uncertainty in potentially critical environmental areas requires a long-term commitment to construct reliable indicators, to build a data base, and to monitor the situation so that we can make informed public policy decisions and evaluate the efficacy of specific government programs.

Measuring the Health of the Environment

Who cannot identify with the young mother who, with shaky voice, declares to the doctor that "his temperature is 105 degrees"? The human body is infinitely complex. Any number of things could have caused the fever. It may be impossible to determine the cause of the illness over the telephone. And the fever is but one indicator that the doctor will use in making a diagnosis. But one thing is clear without asking any more questions — a temperature of 105 degrees is much too high. And something had better be done to reduce the fever. Soon!

The temperature of the human body is a sensitive indicator that something is wrong or that certain things seem to be functioning normally. The single measure is a surrogate for a host of variables. We do not have to understand the scientific principles underlying a change in body temperature. It matters little whether the equipment used to measure temperature is an inexpensive mercury thermometer or a highly advanced machine. What matters is that the indicator — temperature — reliably reflects changes that have an impact on human health.

Since 1970, the Council on Environmental Quality has had a Congressional mandate to report each year on the health of the nation's environment. Yet efforts during the past 15 years have produced very few widely accepted and well-understood indicators. Few, if any, serve the same function for detecting environmental health as body temperature serves for medicine.

With current technology, it may be impractical to construct an environmental counterpart to human body temperature that provides such a clear a relationship between the indicator and the underlying condition. Certainly it is as unrealistic to expect a single environmental indicator to measure the totality of environmental quality as it is to use body temperature as the only indicator of human health. The point is simply this: as environmental scientists construct indicators to improve the assessment of environmental conditions and trends, they should consider why human body temperature is such an ideal indicator: It is simple yet reliable, it is easily measured and easily understood; it is based on solid scientific understanding; and it packs a great deal of information into a single number.

This chapter discusses the desirable characteristics of environmental indicators, suggests why so few of them are found in common usage, describes some recent attempts to construct them, and concludes that construction of a representative family of indicators is a critical next step.

The Need for Reliable Indicators of Environmental Quality

The National Environmental Policy Act requires the Council on Environmental Quality to set forth:

"... (1) the status and condition of the major natural, manmade, or altered environmental classes of the Nation, including, but not limited to, the air, the aquatic, including marine, estuarine, and fresh water, and the terrestrial environment, including, but not limited to, the forest, dryland, wetland, range, urban, suburban, and rural environment; (2) current and foreseeable trends in the quality,

management and utilization of such environments and the effects of those trends on the social, economic, and other requirements of the nation. . . ."[1]

The annual reports of the Council contain the best available information related to the nation's environmental quality. Even so, most of the data published in those reports were initially developed for other purposes. Examples of such data are: ownership of land, uses of land, recreational use of National Forests, coal production, catches of commercial fish, energy consumption, water withdrawals, production of chemicals, and exhaust emissions standards. As useful as these data may be for their intended purposes, the nature of their relationship to environmental quality is not specified.

A few indicators contained within the annual report more directly describe the condition of the environment. Examples include: fish kills caused by pollution; toxic residues in fish, birds, and humans; and ambient air pollutant concentrations. Yet for most of these, there is little theoretical underpinning to guide their interpretation as indicators of environmental health.

In 1982 the private, nonprofit Conservation Foundation published its own report on environmental conditions and trends. That report, which was the subject of hearings before the House Subcommittee on Natural Resources, Agricultural Research and Environment in 1983, stated that:

> "Our monitoring of environmental problems is even more deficient than our scientific knowledge. We have no monitoring data sufficient to describe accurately the extent or developing seriousness of any environmental problem. The single national water quality monitoring network often fails to provide useful information on several of the major traditional water pollutants, because the monitors generally are some distance removed from where the pollutants are discharged. EPA's estimates of air pollution emissions are simply rough approximations. They have been drastically revised, for all years back to 1970, three times in the past two years. Each change showed more improvement in air pollution control than the previous set of figures, but the reasons for the changes have not been documented. Except for a few pesticides there is no reliable national monitoring of toxic chemicals."[2]

A subsequent Conservation Foundation report reiterated the point.[3]

The corporate world has also complained about the relative lack of comprehensive and reliable data on the state of the environment. Under the sponsorship of the Council on Environmental Quality, the World Wildlife Fund-U.S. conducted an in-depth survey of the use of natural resources information by 30 of the largest corporations in America, seven trade associations, and eight private information companies. The report was released on May 16, 1984, by Russell E. Train, President of the World Wildlife Fund.[4]

Corporate executives reported that they cannot obtain adequate domestic and international environmental quality data. By contrast, the study found that the government is doing a good job of providing information in such related areas as natural resources and domestic resource supply, and that trade associations excel at providing information on the processes for turning a natural resource into an economic resource.

In a recent conference on long-term environmental research and development,

a group of scientists stressed the need for more work on indicators of environmental quality:

> "Although ecologists measure numerous variables as indicators of change, many measurements are based on inadequately tested assumptions, and most have relatively poor precision with limited potential for improvement. The lack of precision and occasional controversy over the validity of an approach have lessened the effectiveness of ecological inputs to decisionmaking."

> "Data exist that could be used to effectively test the assumptions, accuracy, and precision of measures of ecological change. Some of these data exist in post-impact monitoring of projects for which environmental baseline data and predicted effects were documented in environmental impact statements (EISs). Other data exist in academic or scientific agency studies. Currently there are no organized plans to accumulate and interpret the data, to provide well-documented case histories of cause-effect relationships, or to test various measures of changes. . . . [T]he harvesting of these efforts, especially of the EIS work, should be cost effective."[5]

Based on their conclusions, the scientists recommended additional research to identify early indicators of potential ecological change. Positive changes are as important to policy decisions as are emerging problems.

Since its inception, the Council on Environmental Quality has been an important catalyst for developing indicators of environmental quality. The first five annual reports of the Council chronicle an early recognition of the need for environmental indices and indicators and the development of indicators. In the late 1970s, the Council sponsored an interagency task force to bring about improvements in the way in which environmental variables are monitored.

The Council has begun to renew its efforts to improve the quality of reports on the condition and trends of the environment. Much more can be done to increase the usefulness of existing information by more careful selection, display, and annotation of data collected by government agencies.

Construction of Environmental Indicators

Definitions to Provide a Common Language

As a first step toward construction of indicators, a set of definitions is proposed so that the effort begins with a common language:

Environmental Indicator — An environmental parameter, theoretical concept, or aggregation of data that provides a surrogate representation of some aspect of environmental quality or condition.

Theory — The conceptual framework for documenting the relationship between the indicator value and the environmental parameter for which the indicator value is a surrogate.

Measurement — The assignment of values to one or more environmental parameters.

Data — A set of one or more values assigned to environmental parameters.

Calculation — The process of converting data on environmental parameters into an aggregated value for the indicator.

Index — A type of environmental indicator in which the value is directly referenced to some standard or base value.

Characteristics of a Good Environmental Indicator

Environmental indicators should give quantitative structure to such concepts as "environmental quality," "water quality," "ecological balance," or "environmental health." The indicators should serve as an indirect measurement of those concepts that cannot be directly measured. They should be designed to answer such questions as:

- Is the environment getting better or worse?
- What aspects of the environment are most improved? Most degraded?
- In what regions should we be most concerned? Least concerned?
- Where do environmental conditions pose a health hazard?
- Have environmental legislation and programs resulted in any measurable improvements?

A well-chosen family of indicators should make it possible for policy-makers and the public to assess the general health of the environment and monitor progress toward improving its health.

Numerous indicators in other fields serve these purposes. Some of the more familiar ones from the field of economics and finance include the Dow-Jones Index of stock prices, the Prime Interest Rate, the Unemployment Rate, Disposable Personal Income, and the federal expenditure share of the Gross National Product.

Based on the experience of the Council on Environmental Quality in constructing the Pollutant Standards Index, and the National Oceanic and Atmospheric Administration, in constructing indices of marine degradation, the following goals emerge as appropriate for future construction of environmental indices:[6,7]

1. *They should be easily understood by the layman.* They should facilitate communication of environmental quality information to the public. They should strike a balance between oversimplification and complex technical conceptualizations. The indicators should implicitly impart an understanding of the significance of the parameters they represent.

2. *They should be grounded in scientific understanding.* Environmental indicators should be based as clearly as possible in knowledge of cause/effect relationships. Ideally, the theoretical construct on which the indicator is based would document how perturbations in the environment, such as the introduction of chemicals, affect indicator values, and what specific levels of indicator values are associated with excessive risks to environmental and human health.

The reporting of indicator values as higher than or lower than some base may be interesting, but the important question is, what does it really mean? Information about how changes in indicator values impact human and environmental health is crucial in determining how much is too much. Information about what causes these changes in the environment is crucial in determining what can be done about it. Science discovers the cause/effect relationships associated with specific indicator values; public policy determines what action will be taken in response to variations in the indicator values.

3. *They should portray ranges of environmental quality that reflect "normal" conditions, a "problem threshold," and a category that portends serious consequences.* An indicator linked through scientific documentation to human or environmental health consequences should have a means to display those consequences in such a way that personal behavior and public decisions can respond to it. The goal is to differentiate clearly those impacts that are damaging in some way from those that are not harmful and to which we can adapt. Many of these decisions must be based on value judgments, which ultimately involve policy choices. As a consequence, the calibration of ranges considered as "acceptable" or "harmful" on the scale of indicator values should be made jointly by scientists and policy-makers.

4. *They should reflect meaningful variation in environmental quality.* Some environmental variables change very quickly and others very slowly. Air quality may change markedly from day to day or even hourly, as it responds to changes in weather patterns and such man-caused changes as rush-hour traffic. Ground water quality may be affected over a period of years from a single event and is not likely to show significant variations over a short period of time. Indicators and their accompanying monitoring activities should be designed to respond to a timeframe appropriate to the environmental medium that is being measured.

The monitoring of the indicators should be linked to the specific value that the indicator is designed to protect. For example, if the indicator is amount of dissolved oxygen (DO) in the water aimed at the protection of benthic organisms, and the target species cannot survive below a particular level of DO, then the monitoring should be done at the time of day when DO is at its lowest level, and the measurement should be taken from the bottom of the water column where the organisms are located.

5. *They should be easy to calculate from a variety of network sources.* Environmental data typically are collected and stored by a wide variety of entities, public and private. It is uncommon for any single entity to have a monopoly on the information for any given environmental parameter. This is true even in areas where there is a recognized, authoritative source of information and expertise. For example, the U.S. Geological Survey is the acknowledged center of expertise on water availability in the nation, but a substantial portion of the information on the subject is collected by other federal agencies, universities, municipalities, trade associations, and others. Full utility of the information is greatly enhanced through the creation of networks through which the information can be shared, with a minimum of costly restraints.

6. *They should allow for both aggregation of data to display national trends in environmental quality and for disaggregation to show local/regional conditions.* From a broad policy perspective, overall trends for the country are important. But for decision-making to resolve problems or avoid them, it is equally important to show where the problems are most severe.

7. *They should be acceptable in terms of cost.* The monitoring of environmental indicators can be very expensive. However, costs can be minimized, for example, by careful selection of variables to be measured, by linking into existing data-gathering networks, by concentrating monitoring in known problem areas, by monitoring only as frequently as needed to detect meaningful changes, and by cooperative development of standard monitoring methods that allow states and the private sector to contribute to the monitoring system.

Example of an Environmental Quality Indicator

Ten years ago, a CEQ study revealed great diversity and lack of consistency in the air pollution indices then in common usage in the United States.[8] Indices used by cities and states differed greatly from each other and from the indices that appeared at the time in the scientific literature. The diversity tended to impede interpretation of national air quality. Because of the myriad of bases on which the indices were calculated, even comparison of pollution levels from city to city was impossible.

An incident occurred during the study that added a personal dimension to the problem. One of the authors was contacted by a person who was considering job offers in two different Southern California cities. He wanted to know the frequency with which the air pollution index in each city reached unhealthy values. Both cities monitored air quality, so the information was theoretically available to answer the question. However, because the two cities used different indices, there was no basis for comparison, and no information could be provided the job seeker to assist him in making the decision.[9]

In 1975 CEQ organized the Federal Interagency Task Force on Air Quality Indicators to bring together the federal agencies involved in managing the nation's air quality and others with special expertise to develop a uniform air pollution index for local use throughout the United States. The group constructed the Pollutant Standards Index (PSI), based on National Ambient Air Quality Standards and health-related criteria.

The PSI includes five pollutants: carbon monoxide (CO), sulfur dioxide (SO_2), total suspended particulate matter (TSP), photochemical oxidant or ozone (O_3), and nitrogen dioxide (NO_2). Health related standards and cause-effect information existed for all five. Health consequences result from different concentrations of the various pollutants. The index is standardized on a scale from zero to 500, in which 100 is the value assigned for each pollutant when its concentration equals the standard. PSI values are assigned progressive health related descriptors of "good" or "moderate" when a pollutant is below the standard, and "unhealthful," "very unhealthful," and "hazardous" when a pollutant is above the standard. (See Table 1–2, Chapter 1.) The Task Force report was signed by Russell Peterson, then Chairman of the Council on Environmental Quality; Russell Train, then Administrator of the Environmental Protection Agency; and Elliot Richardson, then Secretary of Commerce.[10]

At the present time, the Pollutant Standards Index is essentially *the* indicator of air quality in the United States. Its use is now required by law. Los Angeles and Colorado use a slightly modified version, but the essential components of their indices are the same as the PSI. The PSI is the basis for the television and radio reports of air quality on the daily news.[11]

CEQ Background on Environmental Indicators

In the early days of the Council on Environmental Quality, the construction of environmental indicators and indices was seen as crucial to the fulfillment of the Council's mandate to report on the condition and trends in the environment.

In its first Annual Report, the Council cited the mercury problem, which

had been detected only after it had become critical in some areas, as partial justification for an environmental early warning system. To obtain such a system, the report continued, would require identification of the environmental parameters that are or should be measured and the construction of indices from baseline data of these parameters.[12]

In 1971, the Council reported the results of a study on monitoring in which one goal was to identify indices and indicators of environmental quality and the data needed to obtain such indices. The study found no general agreement on the requirements for or nature of environmental quality indices. More than 100 environmental indices were proposed for future consideration, selection, and refinement. The report acknowledged that "it may take several years before a comprehensive set of indices has been determined, and it will take a number of years before truly reliable data can be obtained for all of these indices."[13]

The 1972 Annual Report contained an entire chapter on environmental indices and reported condition and trends information on the basis of several indices. The report noted, however, that the indices used were still very tentative. As is still true, air pollution indices were more advanced than those in any other environmental area. The report stressed the relationship between indices and good monitoring. Indices could provide direction to monitoring efforts, and monitoring accuracy, comprehensiveness, and timeliness are crucial to confident evaluation of index values.[14]

In 1973 the Council cited several examples of the construction and use of environmental indices by states, localities, and business firms. The Council had published a *Federal Environmental Monitoring Directory* to assist other organizations to obtain data necessary for the computation of environmental indices.[15]

The 1974 Annual Report summarized the results of attempts to develop wildlife indicators of environmental quality. In a discussion of environmental indices, attention was drawn to the difficulties encountered in their development and use: lack of consensus on index design and weighting of factors; serious concerns about the limitations of data once they are "hidden" in indices; and the losses of information associated with the mathematics of index calculation. Failure to develop meaningful indices, indicators, and other interpretive techniques, the report stated, will result in some misdirection of resources expended on environmental monitoring and data processing. In response to reader suggestions for basic statistical information, the report contained a series of tables that set the pattern for subsequent CEQ reports. Twenty-five contained readily available data on populations, natural resources, commercial production, and energy; only five tables (four on air quality and one on water quality) specifically addressed environmental conditions.[16]

By 1976, the Council had shifted from the construction of indicators to the presentation of statistics:

> During the past 5 years, CEQ has developed an array of environmental indicators and statistical series, conducted studies on environmental issues, conditions, and trends, and published special and annual reports on these topics. Through such activities, and through the collaboration and independent efforts of other federal agencies, it is now feasible to begin the regular publication of two new periodic

federal documents which will provide a reasonable comprehensive and authoritative overview of environmental conditions and trends through the use of graphic indicators and statistical presentations.[17]

In the mid-1970s, the focus of CEQ effectively shifted from the development of environmental indices and indicators to the publication of environmental data and examination of the problems associated with environmental monitoring.

In 1975 CEQ published the *National Environmental Statistical Report*, containing some 200 statistical tables selected on the basis of their relevance to the various areas of environmental quality. Three years later, the Council published *Environmental Statistics 1978*. The approximately 200 tables were selected on the basis of their utility in revealing trends or changed conditions.

During the latter part of the decade, the Council on Environmental Quality also played a major role through its leadership of the Interagency Task Force on Environmental Data and Monitoring. The Task Force was established by the Council in 1977 to review environmental data and monitoring programs and to make recommendations that would improve the effectiveness of the programs. The Task Force, representing more than 25 agencies and bureaus, completed its report in 1980.[18] Among the problems cited by the Task Force were:

1. Fragmentation among monitoring programs and lack of coordination.
2. Inadequate level of quality assurance in most monitoring programs.
3. Difficulty in finding easily retrievable and compatible data from different media (e.g., air, water, land) with which to conduct cross-media analysis.
4. Lack of focus to the fragmented efforts to collect ecological data.

The Task Force made a number of recommendations ranging from new institutions to handle elements of the problem to procedural improvements that should be the responsibility of individual agencies.

In 1981 the Council published *Environmental Trends*. The goal was to include data series that measured environmental changes associated with economic welfare, human health, recreational opportunity, aesthetic appreciation, and concern for ecological diversity and stability.

It was recognized by the authors of *Environmental Trends* that:

> Improving environmental statistics is an evolutionary process. The agencies of government that collect and assemble environmental statistics are continually revising old series and developing new ones. We hope that *Environmental Trends* will be a useful tool in helping to develop a consensus on some of the most important statistical series for measuring environmental quality, by highlighting gaps in needed information and by strengthening the quality of existing series.

The "evolutionary process" of reporting environmental conditions and trends began with the search for indicators, moved to publication of statistics, with increasingly refined selection criteria, broadened to examination of monitoring problems, and culminated in a relatively consistent data series in the CEQ annual reports.

What is needed next is a more systematic development of theory designed to demonstrate how observed changes in the environment actually affect human health, economic welfare, and ecological integrity. This development of theory

may result in deletion of some indicators now in use, refinement of others, and even the addition of indicators not now in common usage.

Recent Activities in the Construction of Indicators

Over the last three or four years, there has been a resurgence of interest in environmental monitoring and the development of indicators for measuring the quality of the environment. This interest has been noted in both the legislative and executive branches of the federal government, at the state level, and in the private sector. Some of the more notable examples within the federal government sector are described below.

1. *Environmental Protection Agency — Monitoring Strategies.* The Environmental Protection Agency has required, by each of its organizational units that are involved in some sort of environmental monitoring, the development of a monitoring strategy. These strategies are to be updated annually.

One of the goals of the agency's environmental monitoring policy statement is to "identify present and future environmental and health problems through national, Regional, State, and local baseline and trend measurement. . . . Wherever appropriate, in addition to changes in environmental quality, these measurements should provide a basis for assessing or estimating exposure of and/or direct effects of pollutants on humans, animals, fish, and plants, and the risk of environmental damage."[19]

This activity does not directly require the construction of new environmental indicators or the refinement of old ones, but it is a step in the direction of aligning monitoring efforts with the specific objective of measuring changes in environmental quality.

2. *National Fisheries Survey.* The Environmental Protection Agency, in collaboration with the U.S. Fish and Wildlife Service, recently completed a study that is built upon a simple but instructive indicator. The intent was to assess the biological health of the nation's rivers and streams. The source of information was not direct measurement in the stream, but the professional judgment of the most knowledgeable fish and game biologists in each state.

Biologists were asked to estimate the health and diversity of fish in each of 1,300 statistically selected streams. Each of the selected streams was ranked on a relative scale from zero, for inability to support any fish, to five, for the maximum ability to support desirable fish species. The health and diversity of the fish community was assumed to be a good indicator of the overall health of a stream; that is, it would indicate whether a stream meets the "fishable" goal of the Clean Water Act.

The survey found that 67 percent of the nation's rivers and streams have at least a minimum ability to support sport fish or other fish species of special concern. In 91 percent of waters, this ability has not appreciably changed; in five percent of waters it had deteriorated, and in four percent it had improved.[20]

The survey used biological conditions as an indicator for several reasons. Presence or absence, abundance, and type of organisms present in a water body can provide useful information from a monitoring and management perspective. Displayed over time, trends in biological conditions can provide decision-makers with information useful in making changes in management strategies for both fisheries and water quality.

The fish community, especially sport fish and species of special concern (for example, threatened and endangered species), were selected as the biological indicators because they are generally present in most perennial water bodies and they react to changes in water quality and quantity through such observable responses as mortality, migration, changes in community composition, and reproductive success. Furthermore, most state fish and game agencies have concentrated their efforts on acquiring data on sport fish populations. This base of data and professional knowledge can result in cost-effective monitoring of trends, without the use of special, on-the-ground equipment.[21]

3. *Indices of Marine Degradation.* The National Oceanic and Atmospheric Administration of the Department of Commerce has been working on the development of several indices of marine degradation. The indices are based on field observations and are expressed in terms of explicit ecological effects. The indices are being designed to be interpreted readily, without reference to additional standards or similar reference values. Each index indicates the relative importance of particular measures, as compared to some type of standard. (See Figures 10–1 and 10–2.)

The NOAA indices are in varying states of refinement. The effort began in 1982, in response to House Subcommittee on Oceanography deliberations about a more tangible, quantitative definition of "unreasonable degradation" as employed in the Marine Protection, Research and Sanctuaries Act. The initial impetus for indices was the desire for more quantitative, scientifically acceptable scales of marine pollutant degradation that would facilitate social definitions of "unreasonable degradation."

The NOAA scientists are grappling with the question of "ecologically important impact," in an attempt to measure those variables that really matter both to the ecologist and the decision-maker. The issue of ecologically important impact is approached by considering it under two questions: (1) is it important enough to justify scientists' warnings to decision-makers; and (2) is it important enough to justify action by decision-makers?[22] The NOAA scientists recognize that criteria for such justification must be based not only upon data analysis, but also on professional interpretation in the context of judgments about a social issue.

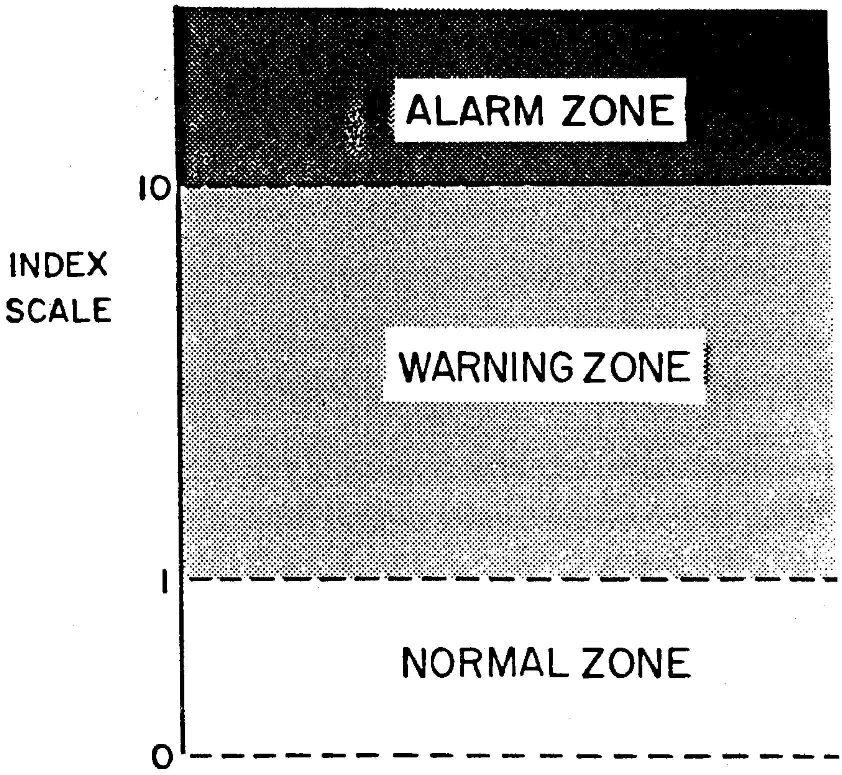
The NOAA scientists are attempting to reach consensus among scientists about what level of environmental degradation is ecologically significant. Furthermore, they are consulting with decision-makers to make certain that the indices developed are acceptable within the context in which decisions are made.

Three workshops have been held, resulting in preliminary identification of a set of indices in September 1982. (See Figure 10–3.) Extensive exchange within and outside the scientific community preceded testing and evaluation of the indices from mid-1983 to April 1985. About 50 selected scientists are actively contributing to the testing and evaluation. The decision-makers' perspective has been sought informally throughout the process. In November 1984 an overview of progress on the indices was presented to environmental managers from state and federal agencies. The program of lay-evaluation is continuing.

Of the 11 indices proposed for consideration, the greatest interest has been expressed in Oxygen Depletion, Pollutant Stress in Sediments, Human Pathogen Risks, and Benthic Species Composition and Abundance. It is uncertain which

FIGURE 10-1

SCALE AND LEVELS OF CONCERN FOR THE INDEX OF FISH AND SHELLFISH DISEASES



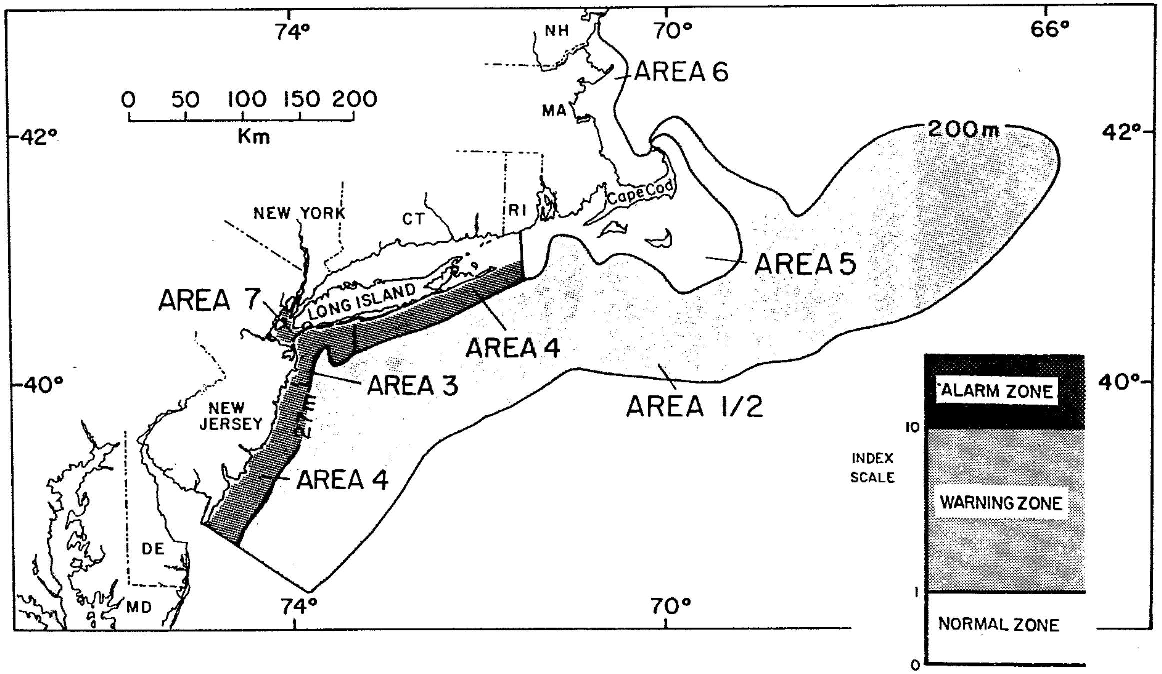
SOURCE: J. S. O'Connor and R. T. Dewling, "Indices of Marine Degradation, Their Utility, *Environmental Management* (In Press).

of these indices will pass the ultimate test — full implementation by the scientific community and use for policy guidance by decision-makers. In the meantime, the process used by NOAA in developing and seeking acceptance of the indices should serve as a useful example for other similar efforts.

4. *"STEP Report."* In 1983, the Association of State and Interstate Water Pollution Control Administrators (ASIWPCA), under a cooperative agreement with the Environmental Protection Agency, worked with the states to assess progress in protecting surface waters. The states looked at the 354,000 miles of river

FIGURE 10-2

SAMPLE MAP: INDEX OF MARINE DEGRADATION



SOURCE: Robert A. Murchelano and John J. Ziskowski, National Oceanic and Atmospheric Administration.

P00000123472

FIGURE 10-3: PROPOSED INDICES OF COASTAL DEGRADATION

Dietary Risks from Toxicants in Marine Foods
Pollutant Stress in Sediments
Pollutant Stress in the Water Column
Human Pathogen Risks
Benthic Species Composition and Abundance
Fish and Shellfish Diseases
Fecundity in Fish and Shellfish
Mortality in Eggs and larvae of Fish and Shellfish — Field Measurment
Mortality in Eggs and Larvae of Fish and Shellfish — Labratory Measurement
Reproductive Success in Marine Birds
Oxygen Depletion

Source: J.S. O'Connor and R.T. Dewling, "Indices of Marine Degradation, Their Utility," *Environmental Management* (In Press).

for which they had water quality information for the entire decade since 1972.

In a report published in 1984, the states reported that 47,000 miles of streams got better, 11,000 miles got worse, and 296,000 miles stayed about the same. Similar trends were noted for lakes and estuaries.[23]

This report represents the first time that EPA and the states have agreed on a set of indicators to describe progress in carrying out mandates of the Clean Water Act. ASIWPCA's proposal to design a system for streamlined reporting and to develop common definitions for water quality evalution resulted, late in 1982, in the initiation of this project labeled "STEP" as shorthand for "States' Evaluation of Progress" in the Clean Water Program.

States used actual monitoring data where available, but because data and records often were limited or unavailable, the responding states supplemented monitoring results with their professional judgment and direct observations.

5. *National Water Summary.* To help answer the recurring question of whether the quality of the nation's water is improving or deteriorating, the National Stream-Quality Accounting Network (NASQAN) was established by the U.S. Geological Survey (USGS) in 1972. The system was designed to (1) account for the quantity and quality of streamflow within the United States; (2) indicate how stream quality varies from place to place; and (3) detect changes in stream quality over time.[24]

Recently, data from the NASQAN system were analyzed for the eight-year period 1974 through 1981 to detect trends in selected water quality constituents and properties in the major rivers in the United States. As an indicator of water quality, the USGS used for each water quality constituent: number of stations with increasing trends, number of stations with decreasing trends, and number with no change. The summary of trends is shown in Table 10-1.

6. *National Wetlands Survey.* The U.S. Fish and Wildlife Service established a National Wetlands Inventory Program about 10 years ago, which recently has resulted in analysis of status and trends of wetlands in the United States. The indicator is expressed simply in terms of acres gained or lost. Gain/loss figures

TABLE 10-1. Summary of Trends in Selected Water-Quality Constituents and Properties at NASQAN Stations, 1974–81

Constituents and properties	Number of stations with— Increasing trends	No change	Decreasing trends	Total Stations
Temperature	39	218	46	303
pH	74	174	56	304
Alkalinity	18	207	79	304
Sulfate	82	182	40	304
Nitrate-nitrite	76	203	25	304
Ammonia	31	221	30	282
Total organic carbon	36	230	13	279
Phosphorus	39	232	30	301
Calcium	23	198	83	304
Magnesium	50	208	46	304
Sodium	103	173	28	304
Potassium	69	193	42	304
Chloride	104	164	36	304
Silica	48	213	41	302
Dissolved solids	68	183	51	302
Suspended sediment	44	204	41	289
Conductivity	69	193	43	305
Turbidity	42	199	18	259
Fecal coliform bacteria	19	216	34	269
Fecal streptococcus bacteria	2	190	78	270
Phytoplankton	22	234	44	300
Dissolved trace metals:				
Arsenic	68	228	11	307
Barium	4	81	1	86
Boron	2	15	3	20
Cadmium	32	264	7	303
Chromium	12	152	2	166
Copper	6	83	6	95
Iron	28	258	21	307
Lead	5	232	76	313
Manganese	30	250	19	299
Mercury	8	194	2	204
Selenium	2	201	21	224
Silver	1	32	0	33
Zinc	19	251	32	302

Source: Smith, R.A., and R.B. Alexander, *A Statistical Summary of Data from the U.S. Geological Survey's National Water Quality Networks*, Open-File Report 83–533, 1983.

are reported by type of wetland and geographical location, such as flyway, state or region. The survey does not provide information on gains and losses in the quality of the various wetland types.

The objective of the study was to develop statistical estimates of acreage for categories of wetlands and deepwater habitats for the lower 48 states during the 1950s and 1970s, and the change that occurred between the two time periods. All wetland and deepwater habitat changes were categorized by cause of the change, either natural or human-induced.

The first "status and trends report" was published in 1983.[25] It provided a detailed accounting of the wetland gains and losses by wetland type. A 1984 report also identified key regions of the country where wetlands remain in greatest jeopardy and provides management recommendations for improving wetland protection.[26] As a complement to status and trends reports, the Fish and Wildlife Service prepares detailed wetland maps that now cover most areas of critical concern. These are intended for use in impact assessments on site-specific projects.

Constraints on Construction and Use of Environmental Indicators

> "An environmental index [or indicator] shouldn't be more difficult to produce than an economic index. . . . Many of the environmental measurements from which we obtain indices are based on well-known physical, chemical, and biological principles.
>
> "Now for the bad news. Over the past half century, economists have built up a strong theoretical base for the indices they use. . . . Environmentalists are not as fortunate. Most professional environmental scientists have confined themselves to fairly narrow fields, and comparatively few have tried to integrate all the accumulated knowledge and data. . . .
>
> "An environmental index isn't really more difficult to produce than an economic index; it takes different talents, but the same hard and continuing work."[27]

The question remains. Why are there so few environmental indicators in common usage today? Or why is there so much reliance on data from other fields as substitutes for indicators of environmental quality?

1. *Professional perspectives.* Perhaps one of the most basic reasons why there are so few indicators is what we might call the professional perspective of the environmental science field. Each profession develops, in addition to its unique scientific knowledge, a unique way of looking at the world.[28] For example, the field of economics structures a large body of theory around the concept of "economic man." Perhaps no single individual in the world behaves precisely like the economic man is supposed to. But as long as the theory constructed around the concept can explain and predict actual economic phenomena with a fair degree of consistency and plausibility, economic man can continue to be the focal point of the profession.

Similarly, other professions have their own way of looking at the world, which guides their conduct and interpretation of research and their development of theory. The vast amounts of medical research are guided by the professional

perspective that human life is of utmost importance. Engineering research is guided by a professional perspective that problems can be solved by the implementation of some physical or structural improvement. Agricultural research is guided by the professional perspective that crop yields can and should be increased.

It may be premature to consider as a distinct profession the collection of disciplines that fall under the rubric of environmental science, for within many traditional disciplines, such as engineering, health sciences, and law, there have developed sub-specialties related to the environment. Yet within the central environmental disciplines — notably the ecological and biological sciences — there does emerge a professional perspective that guides the conduct and interpretation of research. The environmental perspective focuses on the complexity of the myriad of interrelationships that make up the whole of the natural environment. Environmental scientists display an aversion to generalization, especially when it crosses disciplinary lines. The natural world that forms the basis of our living environment is, they believe, so complex and variable that generalization only distorts reality. While economists use generalization to explain the complex, environmental scientists use complexity to avoid generalization.

Environmental scientists focus on the unique. Much of their research involves the systematic measurement of unique events and situations. When they have enough information on a collection of unique events and situations, they can make generalizations. But they never have enough. This professional perspective stands in the way of development of environmental indicators. Indicators are, after all, a form of generalization.[29]

2. *"Tragedy of the Commons."* Data on property and commodities that are privately owned and traded (e.g., pesticides and energy) are more likely to be developed and maintained than data on non-owned common resources (e.g., fish and water quality). Indeed, most of the "environmental" data in common usage were developed to serve commerce-oriented clienteles.

3. *New Kid on the Block.* Environmental science is a relatively new field of public policy. The demands for information created by environmental impact statements, reporting requirements of the National Environmental Policy Act of 1969 and other environmental legislation, as well as increased public awareness, are a product of the past 15 years. By contrast, in long established natural resources fields, such as agriculture, mining, water resources, oil and gas, and forestry, a series of information and data support programs has evolved within their associated governmental agencies.

4. *Diminishing Returns.* The environmental science field is already using the "easy" sources of data and has developed the "easy" indicators. Air quality is the only area in which there is a widely accepted, widely used environmental indicator based on an accepted body of theory. Air pollution was one of the most visible environmental problems to the public, air quality is measurable, and the field is supported by a large body of theory developed for weather forecasting. Water quality may be the next area in which indicators can be constructed and widely accepted, but technical problems associated with monitoring, data analysis, and extraneous factors, such as water flow levels, are much more difficult to resolve than in the air quality arena. In other areas, such as aesthetics, ground water contamination, wildlife, and quality of life, the

difficulties associated with definition, selection of key parameters, theory, research, measurement, and monitoring are much more severe than those related to either air or water quality. In developing a family of indicators of environmental quality, each additional indicator will be more difficult than its predecessors.

Future Efforts

Fifteen years after the Council on Environmental Quality began its quest for environmental indices, the Pollutant Standards Index is still the only indicator of environmental quality based on solid theory and is widely used and widely accepted in the environmental community. There still is little agreement in the environmental science community about the health of the environment or even about how it is to be measured.

What family of indicators should be used as the standard for measuring environmental health? When answers to the question are obtained, environmental monitoring programs can be made more cost-effective because they select for those parameters that really do reflect environmental health and exclude those parameters that do not; because documented indicators can become standards in the field, which are measured by all levels of government, as well as the private sector; and because the basis for public policy choices would be plainly evident.

The Council will be convening an interagency panel to publish a 1986 version of *Environmental Trends*. To support this effort and to make the report represent the best available data on environmental health, the panel will attempt to move toward agreement on a family of environmental indicators and strengthen their theoretical underpinnings.

Setting Environmental Research Priorities

Science provides the technical basis of our approaches to the protection of the environment. The products of environmental research lead to the directions for minimizing future environmental risk and for predicting and responding to events that we have come to recognize as hazardous. Thus, CEQ considers and disseminates research results.

Years of training and research experimentation are often required before basic research produces results. While serendipity is sometimes a factor in research breakthroughs, discovery is ultimately built upon an established foundation of scientific knowledge. During 1984 CEQ conducted a review, at the request of the Environmental Protection Agency (EPA), of long-term environmental research and development (R&D) to examine the sufficiency of this scientific foundation and to identify initiatives in areas of weakness. In particular, CEQ sought to identify those areas of long-term environmental R&D requiring increased public and private sector attention during the remainder of the century.

As used here, long-term environmental R&D includes three kinds of activities: (1) anticipatory research, designed to identify potential environmental problems before they occur; (2) investigations of a continuing nature, such as ecological baseline studies or epidemiological studies, which may require a period of up to several decades to complete; and (3) fundamental research, the output of which may advance basic understanding of health- or environmental-related

processes. It was thought that a government-wide overview, from the perspective of the Executive Office of the President, would lead to a productive approach to problems of common interest.

The success of this review required the availability of broad scientific expertise. The National Science Foundation (NSF) agreed to work cooperatively by providing staff time and financial resources. These resources plus support from EPA, the National Institute for Environmental Health Sciences, the Department of Energy, and the Nuclear Regulatory Commission made this approach possible.

Formation of Interagency Committee

CEQ established an interagency committee on long-term environmental research to oversee this project. As its first task the committee set boundaries for those long-term environmental research and development (R&D) topics to be covered. The terms "long-term," "environmental," or "R&D" do not have commonly accepted definitions or scope, nor did CEQ believe that any one agency should characterize what the scope of these definitions should be for the entire executive branch, or submit its own agenda. Instead, the committee requested that the participating agencies, using their own respective definitions, characterize the issues of greatest concern to them. Criteria for selection of issues were: (1) their general applicability to all environmental agencies; (2) the 15-year, long-term view; and (3) the relative importance of each particular issue. The issues formed logical clusters. These clusters in turn defined the themes for each of the four panel meetings.

The panels addressed the following four themes:

- Human Health Impacts and Their Mitigation
- Geochemical and Hydrologic Processes and Their Protection
- Environmental Impacts and Their Mitigation
- Monitoring, Assessment, and Environmental Management

Four subthemes were selected for each of the four panel meetings, and for each panel meeting two background papers were prepared on each subtheme. Thus, each panel typically included eight paper preparers and the same number of panelists to discuss the subtheme areas. The papers served as a springboard to a more general review of the long-term research implications of the specific thematic areas. Panelists included public and private sector representatives. A rapporteur provided a report summarizing the discussion. (A detailed listing of panel topics and subtopics is included at the end of this section.)

After all panel meetings had taken place, a fifth meeting was convened at which the panel chairmen, rapporteurs, and CEQ and NSF staff met to summarize the conclusions and recommendations of the respective panels and to identify overriding or cross-cutting long-term environmental R&D issues. The following sections report the outcome of that meeting, reflecting the broad consensus of the panelists as synthesized by the panel chairmen and rapporteurs.

Panelists' Observations

Scientists knowledgeable about health and the environment recognize that certain manmade impacts placed upon natural resources, both living and nonliving,

are more severe than previously suspected. For instance, potentially health-threatening ground water contamination is a problem of increasing concern in the United States, and chemicals placed in hazardous waste dumps and underground storage may pose serious health and environmental threats. Analogous problems with toxic chemicals have been experienced with air and water and in the workplace.

During the past 40 years a wide variety of new synthetic chemicals have been introduced, some of which appear to pose serious acute and chronic health effects. Of similar concern is evidence of potential and perhaps irreversible damage to such important natural processes or properties as biogeochemical cycling or biologic diversity. Examples of possible changes in natural ambient levels that may be precursors of damage to health or ecosystems include the observed gradual increase in atmospheric carbon dioxide concentrations, suspected increases in atmospheric methane concentrations, possible increases in nonurban concentrations of ozone and carbon monoxide (current monitoring efforts detect primarily urban changes), observed increases in rates of species extinction in various parts of the world, and substantial ecosystem degradation in estuarine environments.

Ignorance about many scientific questions has resulted in acknowledged problems of environmental management, such as inappropriate regulation in the face of data uncertainties or heightened public anxieties. Long-term environmental and health research is needed to resolve scientific uncertainties, to establish baseline health and environmental parameters, to overcome lack of understanding of the short-term variations in natural systems, and to identify long-term trends and relate them to their causes.

For a variety of reasons, current incentives for private sector and governmental support of environmental and health R&D favor short-term approaches. Regulatory agency research programs are generally designed to support mission goals of the agencies sponsoring them, resulting in relatively short-term research planning horizons that do not extend beyond immediate regulatory programmatic requirements. Similarly, corporate research efforts frequently support near-term product development strategies and, at best, are limited by the planning horizons of the firm. Current government and public concern over such environmental phenomena as acid deposition (acid rain) illustrates the limitations of exclusive reliance on short-term research design. Although the potential environmental effects of acid particulates were pointed out years ago, relatively little research attention was devoted to following up on early studies noting these effects, and commitment of resources could not be justified on the basis of then-current regulatory strategies. Accordingly, long-term acid rain research programs were deferred; had they been undertaken a decade ago, they might by now have been yielding information and predictive models of use to current regulators and policy-makers. As it is, Congress authorized a 10-year acid deposition research program in late 1980. Although the present Administration has substantially expanded and accelerated this effort, many scientific issues will not be resolved before the end of this decade.

The panel chairmen believe that there is need for better direction, coordination, and interdisciplinary integration of long-term environmental and health R&D. Improvements in environmental management will flow from better characterization of environmental phenomena, increased understanding of basic

mechanisms, and the development of more meaningful measures of hazard or harm assessment. The panelists noted the desirability of good long-term monitoring data and accompanying quality assurance to evaluate models used for understanding processes and environmental trends. They believe that lack of validated time series monitoring data, even for gross health and environmental measures, has impeded the expansion of fundamental research programs. Further, they believe, the piggyback of monitoring onto ongoing research activities may well provide useful information at little marginal cost.

The panel chairmen believe that modeling can be an integrating force for the environmmental research community. However, the use of models must be accompanied by continuing efforts to validate them. For example, in constructing quantitative risk assessment (QRA) models, it becomes clear that the unknowns in QRA can only be satisfied by continued basic research on biochemical mechanisms. Efforts to fill modeling gaps, in turn, can provide help in determining the need for and priority of data collection activities.

General acceptance of these observations led to a consensus that the current institutional framework may not assure that long-term research projects can be started, continued, and completed on a multiyear basis. Only with research projects that extend over a substantial period of time will the nation be able to develop the credible and necessary expertise to better rationalize environmental management policies. Environmental science needs a critical mass of talent and resources to approach effectively the challenge of understanding complex environmental and health phenomena. The need to integrate data gathering, modeling, and environmental impact assessment and QRA efforts may require the establishment of centers of excellence, at which this critical mass of talent and resources can be assembled.

Over the long term, environmental science may provide answers to such unresolved questions as the effects of subtle changes on ecosystems, the effects of new technologies, such as biotechnology and microelectronics, on human health, and the effects of global contaminants on ecological processes.

Overriding and Cross-Cutting Long-Term Environmental R&D Issues

The panel chairmen, meeting separately after the completion of the four expert panels, reviewed the individual panel recommendations to ascertain those of cross-cutting interest and overriding concern. The cross-cutting long-term environmental R&D recommendations were those repeatedly discussed by more than a single expert panel; recommendations of overriding concern expressed perceptions of major research gaps or new discoveries holding vast promise. The complete set of recommendations from which these are drawn are to be found in Appendixes to the *Report on Long-Term Research and Development* published by CEQ (March 1985) which contain rapporteur reports for each of the meetings.

It should be cautioned that the long-term environmental and health R&D recommendations presented herein should not be viewed collectively as the comprehensive national R&D agenda for the remainder of the century; rather, they reflect those R&D issues to which substantial *increased* attention should be devoted. The panel chairmen recommended that the federal government accord long-term environmental research heightened priority and a level of

support sufficient that research findings will contribute to the attainment of broad national goals. This level of support need not require additional resources; it will require, however, a continuity in many existing research programs, a continuing commitment to scientific excellence, and an adequate institutional framework.

The following summaries represent the panel chairmen's recommendations for each of 14 principal issues identified for particular research emphasis.

Monitoring

Monitoring yields current and times series information on the status of environmental systems — information used both for environmental management and regulatory compliance. Information gained from monitoring forms the basis for the testing of scientific hypotheses about how environmental systems operate and interact. Panelists believe that the lack of coordinated scientific resources providing institutional sophistication in environmental monitoring, modeling, biostatistics, and ecostatistics accounts for such problems as nonstandardization of monitoring practices and failure to monitor for parameters of greatest importance or relevance.

In the absence of validated data, modeling is frequently the only source of guidance to environmental managers for describing or predicting complex environmental events. Invariably, one or more elements of necessary environmental data is missing, either because we lack the understanding or tools to measure the phenomena or because the cost of measurement is prohibitive. To the extent that monitoring data necessary for model-building are not validated or reliable, models lack predictive value. Environmental models also frequently suffer from over-complexity or from lack of standardization.

In spite of significant efforts expended on the collection of environmental data by a variety of unrelated and uncoordinated state and federal agencies, no adequate system exists for the centralized collection, storage, maintenance, and quality control of such data. The panel chairmen recommended that CEQ foster an evaluation by an appropriate organization of existing physical, chemical, and biological monitoring programs (and extant data associated with them) to identify and stimulate research and development on improving the quality and cost-effectiveness of monitoring programs. Particular emphasis should be placed on determining requirements for biological and environmental monitoring, on identifying pollutants such as toxic chemicals for sampling, and on determining information and statistical requirements for environmental models.

Institutional Capability

With a few exceptions, the current mix of institutional arrangements and resources to design, conduct, and manage long-term environmental research is not well-suited to the long-term research priorities identified herein. The establishment of "centers of excellence" at existing universities, such as those now supported by the National Institutes of Health and by EPA, was discussed as a possible means to overcome institutional limitations. The National Institute of Environmental Health Sciences represents one example of a governmental institution that has successfully supported integrated research over the long

term. Another example is the Long-Term Ecological Research Program supported by NSF's Division of Biotic Systems and Resources. Laboratories owned and operated by EPA, where the research staff are government employees, provide another model. Research laboratories operated by the federal government on contract to universities, university-based consortia, or industry-based research organizations — such as the National Center for Atmospheric Research, funded by NSF, or the national laboratories supported by the Department of Energy — provided still a third model, one at which government-sponsored research is funded on a multiyear basis.

To supplement government support, the panel chairmen recommended that attention be given to seeking sources of environmental and health research funding and ideas from the private sector to the extent possible, and that effort be given to coordinating government-sponsored research with research performed or supported by industry-specific organizations, such as the Electric Power Research Institute, the Health Effects Institute, the Chemical Industry Institute of Toxicology, and the Gas Research Institute.

Molecular Epidemiology and Exposure Estimation

Molecular epidemiology is based upon measurement in the exposed individual of the interaction of a toxic chemical (or its derivative) with a tissue constituent or a tissue alteration resulting from exposure to the chemical. It thus provides an indirect measure of individual exposure.

Recent progress has been insignificant in refining means of detecting and measuring the interaction of foreign chemicals with easily accessible normal human constituents, such as chemical carcinogen interactions with deoxyribonucleic acid (DNA). It is now sometimes possible to detect a few altered DNA molecules out of the millions in a cell. Along with other developments for detection of altered chromosomes in human cells, these refinements mark important advances in our ability to detect and quantify human exposure to foreign chemicals. Potential benefits from molecular epidemiology research are so great as to justify significant expansion. This research may eventually yield accurate markers of exposure and information on the relationship between exposure and adverse health outcomes.

Hazardous Waste Sites

Panelists indicated that substantial data gaps exist at the soil/water/air/hazardous waste interface, and that very little is known or fully understood about underlying geohydrological processes. Current hazardous waste site cleanup actions are routinely commenced in the absence of knowledge about how chemicals move through the soil, how they are transformed, and how modeling can successfully be used to predict air and water contamination. The chairmen recommended that government agencies, particularly EPA and the Department of Defense, integrate well-defined research studies into plans for measurement and remedial action programs at selected hazardous waste sites.

Genetic Diversity/Susceptibility and Biological Mechanisms

Susceptibility to chemical toxicants varies widely in human host populations.

Such host factors as genetic diversity, current or prior disease, sex, and age contribute to this variation. There are approximately 2,000 genetically identifiable human diseases, and there are firm theoretical foundations for the hypothesis that genetic conditions are likely to affect (sometimes dramatically) the risk to affected individuals of developing environmentally or occupationally associated adverse health effects; however, the extent of risk enhancement is currently unknown.

It is recognized that identification of different susceptibilities as a result of genetic differences may generate or exacerbate social programs. Although this variation creates difficulties for the research establishment, it should not be allowed to inhibit scientific inquiry. Many of the differences in susceptibility derive from major differences in the way individuals alter (intensify or decrease) chemical toxicity through their different enzymes (active body constituents that alter foreign chemicals). The panel chairmen recommended that a research effort be mounted to identify genetic and other factors important for individual differences in susceptibility to environmental agents, to assess the health impacts of such differences, and to examine the means (such as differences in enzymatic activity) by which these differences become manifest.

Mixtures

Exposures of humans, other animals, and the natural environment to pollutants rarely involve single substances. Human and nonhuman organisms are generally exposed to mixtures of chemicals, whether from waste dumps, contaminated water, or ambient or workplace air. When single agents can be identified as being of predominant importance, the problem is simplified. Often, however, this is not the case. Regrettably, there are no valid general rules for determining the presence of synergism in inhibitory action, and any study requiring a mixture-by-mixture analysis would be impossibly complex. The panel chairmen recommended, therefore, a major effort to define underlying general scientific principles for evaluating the toxicity of mixtures of chemicals.

Anticipating the Impacts of Emerging Technologies

We lack 10-year observations of the background, physical, chemical, and ecological variations in fresh waters, oceans, and the atmosphere to enable us to distinguish natural changes from perturbations attributable to human activities. We lack continental-scale background information on historic chemicals or even on currently important chemicals in the environment, particularly in coastal waters and the atmosphere. We are also ignorant of the normal range of variations through which ecosystems and their components pass. In addition to obtaining better information on background concentrations or biological variations, the panelists proposed the examination of ecological processes and how pollutants interfere with those processes.

Fundamental Research in Freshwater, Ocean, and Atmospheric Cycles

The panel chairmen recommended an expanded collection of 10-year observations of these phenomena to better enable us to distinguish natural

fluctuations from those caused by anthropogenic activities: these observations should be performed at study sites selected to permit simultaneous observation of contaminated and close-by or ecologically similar but uncontaminated areas. For study of coastal waters, several estuaries have been identified as receiving or having received significant amounts of pollutants; the fates of these pollutants should be continuously monitored. The panel chairmen recommended that long-term continental-scale and global-scale baseline atmospheric measures be gathered for polluting gases, such as ozone, nitrous oxides, sulfur dioxide, and hydrocarbons, and for particulates. These pollutants should be studied to determine their effects on climate, visibility, and variables that affect human health and the quality of life. The panel chairmen also recommended an expanded research effort to describe more effectively the transport and transformation of toxic organic compounds with respect to their physical, chemical, and biological effects in the subsurface soil and ground water environments. Subsurface and ground water research activities should be focused on gaining a better understanding of the interactions of ground water with the solid phases of rocks and soils; on developing a quantitative understanding of the variation of the sorption and vapor pressure of organic compounds with soil moisture, particularly below 10 percent soil water content; and on the fundamentals of hydraulics and geochemistry for low-permeability materials. Given the expense of ground water monitoring, research could most efficiently be coordinated with existing compliance monitoring activities.

Intermedia Transfer

Pollutants move from one receiving medium to another (air to water; ground water to estuary), and their concentrations in any given reservoir depend on the rates of these transfers. Predictions of pollutant distribution within the environment are based on quantitative assessments of these movements. At present, quantitative rate measurements of these intermedia transfers are still rudimentary.

The panel chairmen recommended studies to determine intermedia transfer rates for both description and prediction of the subsequent fate of toxic chemicals in the environment. Of particular interest are aerosol formation rates of chemically reactive organic pollutants and the effects of surface active agents on the air/water interface, precipitation scavenging or aerosols in the field, dry deposition as a function of topological (surface) roughness, volatilization and asorption as a function of temperature and moisture content, and the deposition and resuspension of sediments. Determining the chemical composition of aerosol particles and the size distribution of suspended solids in the liquid phase will also help in understanding these transfer rates. The panel chairmen further recommended that the results of intermedia monitoring and modeling studies be used to develop screening procedures to determine under what environmental conditions and with which chemical substance characteristics it is necessary to consider intermedia transfers. The panel chairmen also recommended linking intermedia transport processes to the biological effects observed in receptor organisms affected by exposure to the transferred chemicals; monitored receptor organisms should include humans, commercially important species, and whole ecosystems. Finally, the panel chairmen recommended that

anticipatory research on the intermedia nature of pollutant transfer be used in the consideration of the respective cost efficiences of alternative multimedia control strategies.

Assimilative Capacity

In the United States billions of tons of solid waste (of which a small percentage can be designated as hazardous) are released to the land, air, surface waters, and ground waters. Wastes also move from one medium to another and ultimately reside or degrade in various media. Assessments must be made of the cross-media risks associated with waste treatment and disposal practices. Each environmental medium and the biological communities that reside within it are assumed to have a site-specific set of responses to different levels of toxic loadings. Various wastes differ on many characteristics, including toxicity, mobility, degradation rates, and their ability to be recycled or otherwise treated. Presumably some amount of certain wastes may be assimilated by the different media without adverse impacts on human health and environmental quality. Identification of the lower limits at which public health, ecosystem integrity, or the most sensitive species populations are affected is crucial to a determination of environmental quality.

Although the panel chairmen recognized that considerable research has been done in some of these subject areas, they recommended that research be undertaken to determine the behavior and biological effects of chemicals in environmental media as a basis for setting levels of release for protection of human health and environmental quality. In addition, the determination of these levels should include a consideration of such changes in the physical environment as global warming, decreases in atmospheric visibility, and their impact during extremes of temperature and moisture encountered after one- to five-decade levels of variations.

Global Biogeochemical Cycles

Global biogeochemical cycles are essential to the maintenance of the biosphere. Continuous interaction between biotic and abiotic components of the Earth distinguishes it from other planets and, thus, the term "biogeochemical cycling." The panel chairmen recommended the conduct of long-term fundamental studies, building on the results of previous research, to characterize the role of biological and physical/chemical linkages and processes in specific biogeochemical cycles (for example, in carbon, nitrogen, phosphorus, sulfur, and oxygen cycles), as well as in their interactions with each other and with climate.

Global Pollutants and Impacts on Ecological Processes

Significant gaps in the environmental science knowledge base reflect our ignorance of cause/effect relationships between global pollutants and ecological processes. The panel chairmen recommended the conduct of long-term studies to identify the biological interactions and ecosystem processes that are most sensitive to specific past, present, and anticipated global pollutants and

environmental stresses. The results of such studies might be helpful in clarifying the impacts of pollutants on the total biosphere and on global chemical processes.

Fundamentals of Ecosystem Structures and Processes

To identify those ecological phenomena that are related to the sustainability of ecosystem resources, and especially to the conservation of biological diversity, there is a need for long-term biological inventories and baseline studies of ecosystem structures and functioning. Especially needed are studies of processes that link different ecosystem types (for example, suburban/urban, agricultural/aquatic, industrial/agricultural linkages). The panel chairmen recommended the identification of ecosystem sites that can be studied and the establishment and maintenance of a national network of representative ecosystem sites, both those that are relatively undisturbed and those that are intensively managed.

Quantitative Risk Assessment

Quantitative Risk Assessment (QRA) has come to play a major role in regulatory processes and in risk management generally. Current QRA techniques are generally acknowledged to be crude and to lack the precision commensurate with the importance attached to the regulatory decisions frequently based on them—decisions that may have significant social and economic consequences.

Scientists now believe that improvements in QRA techniques are more likely to come from better understanding of biological processes than from improvements in mathematics. Far too little is now known, for instance, about virtually any health (other than cancer) or ecological effects, about actual exposure patterns, and about the potential of short-term biological screening to provide early prediction of effects. Further studies are needed on the independent validation of risk assessments, better understanding of decision processes, identification of scientific principles used in selection of assumptions and criteria, determination of the criteria used as a basis for risk assessment priorities, and improving the understanding of risks. The panel chairmen recommended that particular research attention be given to improving the scientific basis for risk assessments and to procedures for valid extension to human health effects other than cancer, such as systemic toxicity.

A Benchmark

CEQ's *Report on Long-Term Research and Development* records the state-of-the-art of environmental research and will serve as a benchmark of our progress in scientific knowledge that is useful for maintenance of environmental quality. CEQ strongly encourages those involved with environmental science to consider seriously the directions identified by the panelists. It is our expectation that continued progress toward environmental quality can be accelerated by research results in the areas identified by the work of the experts who participated in this project.

Biotechnology

With the recent discovery of techniques to alter the structure of cells, particularly the genetic material within a cell, a new set of remarkable tools has been fashioned that adds dramatically to our ability to affect the growth and characteristics of microorganisms. This application of biological systems and organisms to technical and industrial processes has been termed "biotechnology." Modern biotechnology depends primarily on the sciences of microbiology, biochemistry, and genetics. Its applications pervade many disciplines, ranging from agriculture and pharmacology to the mining of ores and metals.

So accepted in everyday life are the products of conventional biotechnology that few realize the extent to which we rely upon the sciences of microbiology, biochemistry, and genetics that underlie biotechnology. Alcoholic beverages and breads are examples of fermentation techniques as old as recorded history. Antimicrobial vaccines, such as penicillin or smallpox vaccine, are marvels of modern medicine. Agricultural plants and animals have long been bred to enhance their yields and desired characteristics by selective breeding.

The power of the modern techniques of biotechnology derives from its ability to create precise alterations in the genetic information of certain cells, thus permitting their growth or function to change. The harnessing of the cells through their controlled growth offers the promise of a new dimension of products as exciting to scientists as the information revolution based upon the microelectronic computer chip. For example, modern medicine now has available human insulin produced by bacteria for obviating present reliance on animal organs for the hormone. Agricultural researchers are developing more precise tools for improving the quality and quantity of foods: refinement in seeds may improve a plant's pest-resistance and reduce fertilization requirements. And a wide range of industrial uses now seems possible for biotechnology products that will increase the efficiency of various techniques, including the extraction of oil or minerals.

The United States government has played a major role in funding the biomedical and other fundamental research that has formed the basis for the new biotechnology. The National Institutes of Health (NIH), through myriad scientific activities seeking better understanding of the molecular nature of disease, has stimulated much of the basic knowledge used by the new biotechnology. Other federal agencies, particularly the National Science Foundation (NSF) and the Department of Agriculture (USDA), also sponsor related research.

Recombinant DNA Concerns

The potential inherent in recombinant DNA (rDNA) techniques of modern biotechnology at first raised concerns in the scientific community and the public-at-large about the safe use of the techniques and the hypothetical hazards they could present. There were concerns that new pathogens could be created; and there were environmental concerns that once in the environment microorganisms, unlike chemicals, could proliferate and establish themselves, thereby damaging the ecology.

In concert with the scientific community, NIH in 1974 established a special federal advisory committee, the Recombinant DNA Advisory Committee

(commonly called "the RAC") to provide scientific advice; in 1976 this group developed the NIH "Guidelines for Research Involving Recombinant DNA Molecules." It was reasoned that a cautious approach to this research was essential to protect health and the environment while fostering the advancement of the new technology. The guidelines established requirements for the use of these techniques in federally funded or conducted research. The primary principle of the regulatory scheme involved the adequate containment, both physical and biological, of rDNA-containing organisms. Subsequent experience gained in rDNA laboratory research and through risk-assessment experiments have mitigated many of the concerns about risks; evaluations of the original guidelines and monitoring mechanisms have led to lessened stringency.

As the results of "genetic engineering" moved from the research arena to the industrial development phase, concerns were voiced about possible untoward effects on human health and the environment resulting from the scale-up of laboratory processes and certain commercial applications of biotechnology products involving their purposeful use outside of a contained enclosure.

Public Policy Issues and the Regulatory Framework

Public policy issues relating to biotechnology span a broad range of concerns for an emerging industry that promises to transform significantly the technological basis of vast sectors of the chemical, agricultural, and biomedical industries. First, there is the issue of adequate personnel and financial resources to continue the fundamental research that has developed biotechnology as we know it today and that will be necessary to refine its development. Second, there must be a positive atmosphere for commercial and entrepreneurial development, capital for financing new industry, trained personnel, laws ensuring protection of intellectual property, effective antitrust laws, international markets, and the like. Finally, there is the issue of appropriate regulatory constraints that will adequately protect health, safety, and the environment while at the same time not stifling innovation. Because of its importance to the national interest, the healthy growth of biotechnology is a major federal policy concern. While there is a complex and dynamic relationship among the various aspects of these policies, the discussion in this chapter is focused on those areas of primary concern to CEQ, namely, health, safety, and environmental protection.

Scale-up and the immediate prospect of environmental applications of biotechnology products or altered microorganisms have raised the question whether existing federal law provides an adequate and appropriate basis for protecting human health and the environment. For example, Congressional hearings held in 1983 on the environmental implications of genetic engineering concluded that "the current regulatory framework does not guarantee that adequate considerations will be given to potential environmental effects of deliberate release."[30] The report of the Committee acknowledged benefits to be derived from biotechnology and stressed the desirability of enhancing the Environmental Protection Agency's (EPA) expertise and efforts in biotechnology, by establishing an interagency task force to review proposals, developing guidelines for environmental releases, and establishing a risk assessment program.

Among three existing federal agencies — the Food and Drug Administration (FDA), USDA, and EPA — there have been programs that regulate, monitor, or encourage the development of products similar to those emerging from the new biotechnology. Each of these agencies enforces a variety of regulatory statutes designed to foster the availability of safe drugs, foods, agricultural and chemical products. Because of the variations among these laws, and because of different approaches in the way that new drug, foods, agricultural and chemical products are developed, there could be corresponding variations in the manner in which new biotechnology products in these areas would be regulated. For example, new drugs are subject to a stringent process of scientifically designed tests to determine safety and efficacy first in lower animals, and then in man. New seeds or other agricultural products receive the equivalent of safety testing through a system of governmental and non-governmental institutions and less formal review mechanisms. EPA, operating under separate laws, has more formalized compliance regimes for new chemicals and for pesticides. The diversity and comprehensive nature of these existing regulatory regimes suggested that there was sufficient legal authority for the protection of health and the environment in uses of the products of the new biotechnology, but some administrative mechanism was needed for better coordination.

On December 31, 1984, a *Federal Register* notice (49 Fed. Reg. 50356) announced an Administration proposal for the regulation of the products and processes of biotechnology. This announcement came 10 years after NIH began oversight of research applications involving the perfected techniques of recombinant DNA (rDNA) from the early 1970s. The 1984 regulatory policy, like the 1974 research policy, proceeded without the enactment of new legislation. Rather, the involved agencies determined that existing statutory authority offered sufficient legal basis to establish controls over the products and process of the new technology.

Of particular note is the *prospective* approach taken. Few of the products of the new biotechnology have been introduced and none has provided any empirical basis for additional concern about public health, safety, or the environment. Nonetheless, in consideration of the conjectural concerns, a decision was made to clarify the applicability of existing regulatory controls. This cautious approach parallels the manner in which applications for rDNA research were first reviewed in the 1970s. Initially, the NIH required full-scale assessment of all research applications. Gradually, as more became known about the technology, simplified procedures were adopted for common research areas, with most experiments exempted from oversight or subject only to notification requirements. Only exceptional protocols now require prior review and approval.

Cabinet Council Working Group on Biotechnology

EPA, USDA, and FDA had independently considered the potential hazards and ways that their respective authorities mandate protection of public health, safety, and the environment. In order to unify Administration policy, the White House established a Cabinet Council Working Group on Biotechnology in April 1984 with membership from a number of federal agencies, including the following: Departments of Interior, Justice, State, Agriculture, Commerce, Defense,

Energy, Health and Human Services, and Labor; Environmental Protection Agency; Council on Environmental Quality; Council of Economic Advisors; Office of Management and Budget; Office of Policy Development; the National Science Foundation; Office of the U.S. Trade Representative; and the Office of Science and Technology Policy.

The Cabinet Council Working Group was charged with the following responsibilities:

1. Review the regulatory requirements that have been applied to commercialized biotechnology.
2. Identify existing laws and regulations that may be applicable to biotechnology.
3. Review the function of the NIH Recombinant DNA Advisory Committee and its role in biotechnology commercialization and safety regulation.
4. Clarify the regulatory path that a company with a new product would follow to meet federal health and safety requirements.
5. Determine whether current regulatory requirements and federal review are adequate for new products.
6. Develop specific recommendations for administrative or legislative actions to provide additional regulatory review if warranted, while maintaining flexibility to accommodate new developments.
7. Review court rulings regarding the granting of patents for biotechnology.
8. Review other federal actions, such as support of basic research and training, U.S. patent and trade laws, and other policy issues that affect commercialization and U.S. competitive positions vis-a-vis international firms.

The importance and timeliness of the group became pronounced a few weeks after its establishment when an opinion urging caution was voiced by U.S. District Court Judge Sirica in the case of *Foundation for Economic Trends v. Heckler* (587 F. Supp. 753 D.D.C. 1984). That case awarded a preliminary injunction preventing the conduct of a particular field test of an altered microorganism and further prohibiting other environmental application experiments by federal grantees until such time that the government prepared an "environmental impact statement" as required by the National Environmental Policy Act (NEPA). On appeal, the appellate court required the preparation of the less detailed "environmental assessment" imposed by NEPA on the experiment in question and lifted the prospective injunction on other experiments. The plaintiffs in this case included several persons who believed that the alteration of genetic material was wrong for moral, ethical, and other reasons, and who decided to pursue a complete ban on the application of the techniques of the new biotechnology. Before they brought suit in federal court to stop or slow down research related to biotechnology, they had argued against approval of similar rDNA research before the Advisory Committee.

The Cabinet Council Working Group is co-chaired by the Office of Policy Development in the White House and the Office of Science and Technology Policy in the Executive Office of the President. The members of the Working Group are policy level, subcabinet officials.

The major achievements of this group during 1984 included drafting a proposed federal regulatory statement, identifying those federal laws that may control biotechnology products and processes, developing a consistent interagency regulatory policy, and proposing interagency mechanisms for reviewing risk

assessments and resolving interagency disputes. The proposed policy statement was published as noted above in the *Federal Register* on December 31, 1984.[31]

The ambit of current federal regulatory control is summarized in the *Federal Register* notice in a chart entitled "Regulatory Matrix," which identifies the laws, regulations, and guidelines that may apply to the products of biotechnology at some stage in their research, development, marketing, shipment, use, or disposal. These requirements are organized into seven parts: licensing and other premarketing requirements; post-marketing requirements; export controls; research and information gathering; patents; air and water emissions standards; and requirements for federal agencies.

The coordination of agency regulatory policy began with independent drafts prepared by FDA, EPA, and USDA. As each of these agencies has substantially different historic and legal bases for its regulatory mandate, these agencies proposed distinctive, agency-specific approaches to controlling biotechnology.

The published *Federal Register* notice combines the separate regulations proposed by FDA, EPA, and USDA. (An additional part dealing with worker safety was subsequently published by the Occupational Safety and Health Administration (OSHA) on April 12, 1985 [50 Fed. Reg. 14468].) Upon examination of public comments received by these agencies and by the Office of Science and Technology Policy, the various agency policy statements and the proposed review mechanisms may undergo significant change.

The Food and Drug Administration

FDA's administrative review of products, including those that in their manufacture employ specialized biotechnological techniques such as recombinant DNA is based on the intended use of products on a case-by-case basis. Although scientific considerations may dictate areas of generic concerns for certain techniques, the use of a given biotechnological technique does not require a different administrative process. Regulation by FDA is based on the rational and scientific evaluation of products and not on *a priori* assumptions about certain processes.

The FDA possesses extensive experience with the administrative and regulatory regimens that are applied to the products of biotechnological processes, new and old, and proposes no new procedures or requirements for regulating industry or individuals.

Although there are no FDA statutory provisions or regulations that specifically address biotechnology products, the laws and regulations under which the FDA operates place the burden of proof of safety and product effectiveness on the manufacturer, except for traditional foods and cosmetics. The administrative review of products using biotechnology is based on the intended use of each product on a case-by-case basis. FDA will treat the products of biotechnology the same as those new drugs achieved through more traditional technology and will subject them to similar rigorous review.

Under FDA law the marketing of new drugs and biologics for human use, and new animal drugs, requires prior approval of an appropriate new drug application (NDA), a license, or new animal drug application (NADA). For new medical devices, including diagnostic devices for human use, either a premarket notification is required for medical devices determined to be equivalent to an

already marketed device or a reclassification petition is required. FDA must pre-clear food additives, including those prepared with biotechnology. The implementing regulations for food and color additives and for affirming generally-recognized-as-safe food substances are sufficiently comprehensive to apply to those involving new biotechnology.

Genetic manipulations of plants or animals may enter FDA's jurisdiction in other ways. For example, the introduction into a plant of a gene-coding for a pesticide or growth factor may constitute adulteration of the foodstuff derived from the plant, or the use of a new microorganism found in a food such as yogurt may be construed as a food additive. Such situations will be evaluated case-by-case, in consultation with the U.S. Department of Agriculture, where appropriate.

The Environmental Protection Agency

EPA has issued proposed regulatory policy under the authority of both the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Toxic Substances Control Act (TSCA). FIFRA provides authority over pesticidal products, including the authority to review and register new pesticides; TSCA provides EPA certain authority over non-pesticidal, non-food, and non-drug products, and requires EPA to review "new chemical substances" before commercial manufacture. These statutes can be applied to certain commercial products of biotechnology, just as they already are applied to chemical and biological products developed by other methods.

The EPA notice primarily addresses microorganisms used as commercial products and emphasizes those areas in which EPA believes its regulations will contribute most to human or environmental safety and where the application of FIFRA and TSCA are most appropriate:

1. A major issue is to determine what information is necessary for assessing the risks posed by nonindigenous and genetically engineered organisms. Although EPA has experience regulating naturally occurring pesticides, concern about potential human or environmental risks specific to nonindigenous and engineered microbes has led to a decision to approach the assessment of any special risks of these microbial products on a case-by-case basis.
2. In response to the issue of at what stage to review certain microbial products before any direct release in the environment, EPA believes that review of small scale testing of nonindigenous and genetically engineered products is necessary to provide adequate protection to human health and the environment.
3. EPA does not propose to address genetically engineered plants and animals as it believes other statutes and regulations are likely to be appropriate for regulating these. Accordingly, EPA will coordinate with the USDA particularly, since certain plant-associated microorganisms may be appropriately the subject of regulation by both agencies.

Because both FIFRA and TSCA are risk balancing statutes that require a balance between the restrictions and higher costs created by a regulation and the lower risks to public health and the environment, EPA will be scrutinizing the risks and benefits of the new products of biotechnology. For example, a

new microbial pesticide may be viewed as more desirable than a chemical pesticide since it lacks the potential for chemical toxicity. Under both statutes EPA's policies will address this balance through the use of the best available scientific information.

FIFRA establishes the EPA's authority over the distribution and use of pesticide products. Before EPA can register a pesticide, FIFRA requires a determination that the pesticide, when used in accordance with widespread and commonly recognized practice, will not cause (or significantly increase the risk of) unreasonable adverse effects to humans and the environment.

TSCA provides EPA with authority to address the risks of a broad range of "chemical substances." Under TSCA, EPA can assess and control exposure to such substances through all phases of their commercial lifecycle — including research and development, commercial production, use, and disposal. TSCA particularly focuses on prevention and emphasizes information development. By requiring EPA to review new substances before manufacture and by giving EPA authority to require testing, TSCA is similar to those regulatory statutes of other agencies that allow action against a risk before harm occurs.

TSCA coverage extends to chemical substances and mixtures used in a wide range of general industrial, commercial, and consumer applications. In the context of biotechnology, products potentially subject to review under TSCA include microorganisms in certain physically contained uses (such as the production of pesticides and other commercial chemicals and the conversion of biomass for energy) and in certain uses involving the direct release to the environment (e.g., pollutant degradation, enhanced oil recovery, metal extraction and concentration, and certain non-food agricultural applications, such as nitrogen fixation).

TSCA requires companies to notify EPA at least 90 days before beginning to manufacture or import a "new chemical substance" for commercial purposes. This reporting requirement is known as a premanufacture notification (PMN).

TSCA generally exempts from PMN requirements new chemical substances produced only in small quantities for research and development. Under the notice EPA is considering removing this exemption in the case of living microorganisms directly released to the environment in order to limit risks from the reproduction and spread of new organisms.

EPA's other program offices may well become involved with the products and processes of biotechnology, for example, with biotechnology approaches to dealing with waste disposal. Accordingly, EPA intends to ensure that the biotechnology activities of its various program offices are coordinated and the expertise in each of these offices is shared.

Department of Agriculture

Under the jurisdiction provided by numerous statutes, USDA regulates and conducts research in animal biologics, organisms and vectors, importation and interstate movement of animals, plants, plant products, noxious weeds, seeds, innoculants, and other articles.

USDA has regulated, monitored, or collaborated in the development of a vast number of biotechnological products and processes, new and old. As one

example, the Animal and Plant Health Inspection Service (APHIS) within the last two years has issued seven licenses under the Virus-Serum-Toxin Act for five products produced by modern biotechnological procedures.

In the agricultural and forestry community there exists a system for the assessment of new cultivars, germplasm, or microorganisms before their commercial release. For decades, the agricultural community, including state, federal, and institutional researchers, have assessed continually the impact of plant, animal, and microbial species in a wide range of cropping and animal production systems, to assure stable agricultural production and protection and preservation of the environment.

Although USDA's initial concerns about the safety of the modern developments in biotechnology were at the laboratory level, technological progress has extended these safety concerns to field research and industrial applications and production. As a consequence, USDA emphasizes the need for agency overview at all stages including research, development, testing, evaluation, production, application, and disposal. To date, according to the USDA notice, no unique or systematic safety problems have been associated with products of genetic engineering, conventional or modern.

The various animal quarantine and related laws provide the authority to regulate the importation, exportation, and interstate movement of certain animals to prevent the introduction and spread of contagious, infectious, or communicable diseases of animals or poultry.

Under the authority of the Virus-Serum-Toxin Act, USDA has regulatory authority over all veterinary biologics imported into the United States or shipped or delivered for shipment interstate.

The Federal Plant Pest Act and the Plant Quarantine Act provide regulatory authority over the movement into and through the United States of plants, plant products, plant pests, and any product or article that may contain a plant pest at the time of movement. The Noxious Weed Act and the Federal Seed Act provide additional authority related to plants, seeds, and their products.

The Federal Meat Inspection Act and the Poultry Products Protection Act empower the Food Safety and Inspection Service to determine the safety and wholesomeness of animals that are slaughtered for human food. Accordingly, there are regulations and procedures for both experimental animals and for many food animals that will receive the benefits of the new techniques of modern biotechnology.

Science Advisory Mechanisms

The *Federal Register* notice states that "regulatory decisions must be solidly based on the best available science." To meet that end, the notice proposes one possible approach relying upon an interrelated group of scientific advisory committees that will assist the regulatory agencies of EPA, FDA, USDA, and the research agencies of NIH (for biomedical research) and NSF (for environmental research). These agency reviews form a first tier of review. A Biotechnology Science Board (BSB), located within the Department of Health and Human Services, will provide a second tier of review for encouraging the sharing of information across agencies and for providing additional review when requested by a particular agency or scientific advisory committee. To promote an interagency

knowledge base, it is proposed that BSB members be drawn from the membership of the agency scientific advisory committees so that two from each committee will be members of the BSB. The BSB will operate under the same time and confidentiality constraints as the respective regulatory or research agency reviews.

International Perspective

No discussion of biotechnology is complete without some mention of the international competition that attends its development. Most of the major U.S. trading partners, including the European Economic Community nations and Japan, are promoting the commercialization of genetic engineering techniques and are reviewing possible regulatory approaches. The U.S. and its trading partners are seeking to ensure an appropriate share of a growing market. Along with the concerns about public health, safety, and the environment, there are corresponding concerns about protection of the underlying intellectual property and the general strength of domestic industrial systems to transform research discovery into viable commercial products.

An international perspective is necessary because the manner in which regulations for biotechnology are implemented in the United States will have direct impact on the competitiveness of U.S. producers in both domestic and international markets. Inconsistent, illogical, or duplicative domestic regulation could serve as a barrier to the export of trade from the U.S. On the other hand, adoption of certification systems by our trading partners that favor their domestic products could create nontariff barriers to trade and block market access. The U.S. is seeking international cooperation on a range of common technical issues, such as the development of consistent test guidelines, laboratory practices, and principles for assessing potential risks.

Acid Rain

Acid deposition or as it is more commonly known, "acid rain," continues to be a complex and controversial issue in environmental science.

There is growing concern about the effects of long-range transport and transformation of sulfur dioxide (SO_2) and nitrogen oxides (NO_x), not only on aquatic systems but also on forest ecosystems, visibility, and materials. The transformation products of these emissions may result in significant ecological damage hundreds of miles from where they are released without respecting state or national boundaries.

The increased concern over long-range transport and transformation of SO_2 and NO_x has led to an upsurge of research activity and several calls in Congress and from environmental organizations for controlling SO_2 and NO_x beyond the current control requirements, which could cost additional billions of dollars annually.

This section provides an account of what is and is not currently known about acid deposition, its effects, the processes that create it, and the response of the federal government to the acid deposition problem.

The Effects of Acid Rain: Knowledge and Uncertainties

Rainfall or precipitation in a clean atmosphere is intrinsically slightly acidic; however, this acidity is aggravated by SO_2 and NO_x.

"Acid rain" occurs when sulfur dioxide (SO_2), emitted primarily by coal-fueled electric utilities, and nitrogen oxides (NO_x), emitted primarily by motor vehicles and electric utilities, are transported in the atmosphere and are chemically transformed to acidic products before being deposited on the ground. Such deposition may either be dry, that is, in the form of sulfate or nitrate particulates or as gaseous SO_2; or wet, that is, with rain, snow, and dew.

In the past, environmental damage due to acid disposition has been most clearly associated with certain aquatic ecosystems and materials and structures. More recently, however, there has been speculation that acid deposition could affect forest growth and crops and, indirectly, human health.

The National Acid Precipitation Act of 1980 created an inter-agency program called the National Acid Precipitation Assessment Program (NAPAP). Under the aegis of this program, studies have been and are being undertaken to elucidate and characterize aquatic, terrestrial, material, and human health impact, if any, of acid deposition. This program also intends to address the significant uncertainties associated with the consequences and process of acid deposition.

Atmospheric Processes

It is generally acknowledged that sulfur dioxide and nitrogen oxide emissions are primary precursors of acid deposition.

National trends show that between 1940 to 1970 sulfur emissions increased by 57 percent. However, from 1970 to 1983, they declined 26 percent; one-third of that reduction took place between 1980 and 1983. In 1983, sulfur oxide emissions totaled 20.8 million metric tons.[32] National nitrogen oxide emissions have tripled over the last 40 years, having apparently peaked in 1979 at 21.1 million metric tons. In 1983, NO_x emissions were estimated at 19.4 million metric tons—a reduction of 8 percent from the peak 1979 level.[33]

Once injected into the atmosphere, sulfur dioxide and nitrogen oxides are transported over long distances by wind currents and undergo complex transformations. These transformations involve a number of additional compounds (including ozone, hydrogen peroxide, volatile organic compounds, and water), which affect the rate at which the primary pollutants (SO_2 and NO_x) are changed into more acidic products.

The complex nature and relationship between the rate and location of emissions and the rate and location of deposit is currently the subject of extensive study and debate. NAPAP research on this problem is intended to address the following uncertainties: (1) what are the important chemical species and processes that govern the formation of acid substances in the atmosphere and how do they operate? (2) what are the meteorological processes governing the transport of acidic substances or their precursors? and (3) how do wet and dry removal processes operate?

An important part of current research efforts under NAPAP is the development of mathematical atmospheric simulation models that can more accurately

predict and analyze the relationship between the sources of primary pollutants and the areas receiving acidic deposition. The Regional Acid Deposition Model (RADM) being developed at the National Center for Atmospheric Research will incorporate all major chemical and physical processes affecting acid deposition on regional scales. Another important activity, sponsored by NAPAP, involves the diagnostic and statistical evaluation of 15 existing European, Canadian, and U.S. models.

Yet another priority effort is the development and operation of a nationwide network to monitor wet and dry deposition. At the end of 1984, there were 142 wet deposition monitoring stations in operation. By the end of 1985, it is expected that 150 will be operational.

Aquatic Effects

The effects of acid deposition on a lake or stream depend on the acidification of that water body, the biological species supported by that body, and the species' sensitivity to acidity.

Acidification of lakes and streams is affected by the rate of acid deposition, the total loading of acid pollutants, the volume of the water body, and the ability of a watershed to assimilate and/or neutralize this deposition. Thus, depending on the geochemistry of soils, the size and buffering capacity of the watershed or body, and the rate of acid deposition, the susceptibility of a water body to acidification can vary widely. Some could be acidified in a matter of years or decades (so-called "direct response" water systems), others in decades or centuries ("delayed response" systems), or even centuries or millenia ("no response" systems). A few lakes and streams in the United States seem to have been acidified due to atmospheric pollution. Acidic lakes (pH below 5.5) have been detected in a limited number of mountainous areas in New York and New England. Other regions of the country may have waters that are sensitive to acid deposition. However, there is as yet no firm understanding of how many lakes and streams have been affected, where they are located, and how many more and how fast they will be affected in the future.

Yet another complex process is important to understanding how watersheds respond to acid deposition. The buffering capacity of soil is a product of the weathering (chemical and physical breakdown) of the bedrock underlying the surface soils. Although current soils have accumulated from thousands of years of weathering, the weathering process still continues and can be enhanced by an increase in the acidity of precipitation. The extent to which "direct response" systems acidify and the rate at which delayed systems move toward acidification can be affected by changes in the weathering rate. Although quantitative understanding of these processes is limited, it appears that "direct response" systems may reach a point of dynamic equilibrium between the deposition rate and weathering rate. If so, the chemistry of these systems would remain stable under unchanging deposition loading.

The "delayed response" system is of particular concern from both a scientific and a policy perspective. There is not yet a good understanding of how many delayed response systems there are, where they are located, the rate at which they could acidify, or the level of deposition reduction necessary for their protection. The number of delayed response systems could be much larger than

direct response systems. Therefore, major consequences of continued deposition at current levels may not yet have appeared in such lakes.

Current research focuses on: (1) conducting a systematic survey of existing surface water conditions; (2) generating a thorough understanding of the mechanisms of surface water acidification; and (3) developing an adequate data base on the physical characteristics of a wide variety of watersheds so that predictions can be made regarding resources at risk from various deposition levels. Research is also being done on whether the acidification process and its adverse impacts on adequate systems can be reversed by liming or other human intervention.

As part of the NAPAP program, the National Surface Water Survey, which includes both lake and stream surveys, has been initiated. Under Phase I of the lake survey more than 1,500 lakes in the Upper Midwest, the Northeast, and the Southeast were sampled by the end of 1984. Sampling of 900 lakes in the mountainous areas of the West and Northwest was scheduled to begin in the late summer of 1985. Phase I is designed to evaluate the chemical status of the lakes and to define the number (by percent, area, and distribution) of lakes that are acidic and/or have low alkalinity.

Phase II will select regionally "representative" lakes and examine temporal variability and the status of fish populations and other biotic resources. Phase III, based on data from Phase I and Phase II, will be a long-term monitoring program on regionally representative lakes. All of this work is important in determining the level of deposition needed to protect differing aquatic systems.

Terrestrial Effects

Scientific knowledge about the effects of acid deposition on terrestrial ecosystems (crops, forests, and soils) is much more limited than that about the effects on aquatic systems. Controlled experiments on field-grown crops have shown little effect from simulated acid deposition. However, the several hypotheses linking air pollutants in general and acidic deposition in particular to observed damage in some forests in Central Europe and at higher altitudes in the eastern U.S. have heightened concern over acidic deposition.

In West Germany, researchers have observed serious problems in many of the forests. In the United States, dieback and decline of red spruce has occurred at some higher elevation forests of New England. Growth reductions and increased mortality in red spruce are also evident in the southern Appalachian Mountains, including parts of North Carolina and Tennessee. Although there is evidence of forest damage and decline in these forests, it is presently unknown whether and to what extent acid rain or its precursors are significant causative agents.

Determining the cause and effect relationship of forest damage is highly complex. Full consideration must be given to natural environmental stresses, such as drought, pests, inter-species competition and past forestry and land use practices, in addition to the several hypotheses that attribute forest damage to exposure, acid deposition, and other associated air pollutants.

Among these hypotheses are:

- Gaseous air pollutants, such as ozone, cause damage to tree foliage, either alone or by interacting with acid deposition.

- The effects of acid deposition on soils promote mobilization and uptake of metals that are toxic to trees.
- Acid deposition results in the leaching of nutrients from tree foliage.
- Nitrogen deposition on foliage provides excess nutrients that extend tree growth into the wintertime, which makes them more vulnerable to a winter frost.

The numerous conjectures regarding the cause of the observed forest damage and the myriad hypotheses of the impacts of air pollutants on forest systems point up fundamental problems in attempting to reduce such damage by controlling air pollution. Even assuming that air pollution is indeed *the* culprit, which pollutant should be controlled further — ozone, SO_2, NO_x, or a combination of all three? Controlling any one of these pollutants does not necessarily result in a reduction of any of the other pollutants. Suppose we controlled SO_2 when NO_x may be the real culprit? Suppose ozone was the culprit, how do we know whether current control efforts — that which have not yet been completely implemented — may not be sufficient?

Under the National Acid Precipitation Assessment Program, research on terrestrial effects is exploring the extent and magnitude of impacts of acid deposition and other air pollutants on forest and agricultural systems. Studies have begun on the effects of air pollutants on forest productivity, reproduction, regeneration, and physiological processes. Crop research continues on testing selected crop species for their sensitivity to acid deposition.

Materials

Material damage includes corrosion of metals, erosion and discoloration of paints, and deterioration of stone structures. Although acid deposition is one of several air pollutants known to damage materials, the extent of damage specifically caused by acid deposition is uncertain for two reasons. First, good data on dose-response relationships are limited, particularly for dry deposition. Such dry deposition includes direct deposition of gaseous SO_2 and deposition of any sulfate particulates onto materials. Second, it is difficult to differentiate between exposure to air pollutants of local origin and those transported from distant sources, such as "acid rain."

As part of the NAPAP program, data are being assembled to support acid deposition materials assessment. The long-term result of the research will produce a comprehensive assessment of the following: (1) the role of acid deposition in materials degradation; (2) the rate of damage to specified materials; (3) the geographic distribution of susceptible materials; and (4) the economic value of materials damage.

Health

Research on acid deposition's impact on human health focuses largely on possible indirect effects — through contamination of drinking water supplies and game fish.

One concern is that acid deposition could cause heavy metals contamination of drinking water. However, a preliminary survey of New England municipal drinking water supplies did not show any demonstrable abnormalities in heavy

metals concentration. It is less clear whether toxic metals problems could occur in private, individual water supplies that rely on rain water to charge cisterns. Additionally, accumulation of heavy metals in fish from some acidified lakes may be a problem. Whether these concerns are genuine is not yet known; if they are, the next step would be to assess the extent of the problem and its impact.

The Response to Acid Rain: Congress and the Administration

Recognizing the importance of the "acid rain" issue and the need for long-term studies, Congress established a 10–year research, monitoring, and assessment program under the National Acid Precipitation Act of 1980 (Title VII of the Energy Security Act).

Known as the National Acid Precipitation Assessment Program (NAPAP), it links the efforts of 12 participating federal agencies with the research and monitoring activities of the states, universities, research institutes, the private sector, and other nations. The program issues annual reports to the President and Congress describing research progress. In addition, the program makes assessments that synthesize technical information. By providing a firm scientific base, the program can serve as a valuable resource for decision-makers in Congress, the Executive Branch, and elsewhere.

Congress has also been considering a variety of legislative measures on acid rain ranging from research and liming lakes and streams to major nationwide rollbacks in emissions. During the past Congressional session, a total of 20 legislative proposals on acid rain have been introduced in the House and Senate, with price tags ranging from millions to billions of dollars annually, and with some having a severe impact on the economic livelihood of thousands. However, with the exception of establishing the NAPAP program, no Congressional consensus on acid rain has been reached.

During 1983, the Administration conducted a thorough review of the state-of-the-knowledge of the acid deposition problem, its nature and extent, options for addressing it, and the costs, benefits, and uncertainties associated with these options. That review recognized that acid rain may indeed be a serious environmental problem; but found that uncertainties on the extent of the problem and the costs and effectiveness of alternative "solutions" made any major response unwise. The Administration elected to continue the control actions already being implemented under the Clean Air Act, but to defer any additional actions. The Administration instead opted for a larger, accelerated research program that would reduce many of the current uncertainties regarding the cause and effect of acidic deposition, allow better identification of whether and which air pollutants are responsible for the adverse ecological impact of the long-range transport of air pollution, and reduce the uncertainties associated with the environmental benefits that may be gained from employing the various options for controlling the various species of air pollutants. Based on such research, rational control strategies for acid deposition can be devised such that the sacrifices that individuals, various states, and economic sectors will necessarily have to make in implementing such strategies will result in a net and identifiable environmental benefit. Accordingly, the Administration stated that "when the fundamental scientific uncertainties have been reduced, [it] will

craft and support an appropriate set of measures to solve the acid rain problem."[34]

In announcing its policy, the Administration made specific commitments to Congress in four areas: (1) to expand and accelerate significantly the acid rain research program (NAPAP), placing particular attention on the key scientific uncertainties that prevent a rational control decision from being made at this time; (2) to make the review of acid rain policy an active and ongoing process, with a specific commitment to communicate the product of its efforts to key decision-makers in the Administration and in Congress as soon as appropriate; (3) to start working immediately with the states to identify and resolve implementation issues associated with a major acid rain program, even though no decision had yet been made on the need for such a program; and (4) as an added measure, to initiate an experimental program on lake liming.[35]

Each of these efforts is being pursued actively. Funding for NAPAP's research effort has expanded from $27.6 million in FY 84 to $62 million in FY 85, with the Administration's FY 86 request reaching $85 million. In addition, the Administration's FY 86 request for funding for acid rain control technology development will exceed $50 million. Congress has appropriated $3 million in state grant monies to support work on acid rain implementation issues.

These efforts represent a sizable commitment both by Congress and the Administration to expediting a resolution of the acid rain issue.

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Chapter 11

International Environmental Issues

This nation's involvement in international environmental issues and programs is diverse and well-established. World population trends, natural resource conservation issues, including wildlife and habitat protection, and industrial pollution problems are all the focus of extensive involvement through treaties and conventions, programs, conferences, and cooperative efforts. 1984 saw continued activity on all these fronts, but some shifts or refinements in policies, most notably in the increased emphasis given to the importance of market incentives, not only in controlling pollution but in encouraging developing countries to achieve their development objectives.

World population growth has often been perceived as a negative force on the quality of life and the environment, especially with regard to developing countries. Programs geared toward family planning have been offered to developing countries by international organizations, nations, and private organizations to help stem historically high population growth rates and thus complement economic development efforts. The United States, in preparation for the August 1984 United Nations International Conference on Population, took the occasion to examine recent world population trends and to reconsider the nation's policy on these matters. In the process, U.S. policy regarding international population issues has been refined.

Prior to the conference, the White House in July issued a policy statement that reaffirmed the nation's long-standing commitment to voluntary family planning assistance programs for developing nations; however, the statement noted that the U.S. will no longer support such programs in nations that use coercion to achieve their population objectives. The policy statement also said that abortion is not an acceptable element of family planning programs; thus the U.S. will not contribute funds for family planning programs to private organizations that perform or actively promote abortion as a family planning method. At the conference in Mexico City, the U.S. concerns regarding abortion and coercion were accepted. The policy also noted the interaction of economic development and population policies and stated that opting for market-oriented economic policies is the most effective way for developing nations to achieve their population stability and economic growth objectives.

The long history of the nation's involvement in international wildlife and habitat protection stemmed from an early concern for preservation in the U.S. Many early preservation and conservation groups formed by private citizens later also played leading roles in the international wildlife conservation movement. Currently, the nation's efforts in international wildlife conservation are extensive and varied. Through government and private programs, the U.S. is undoubtedly doing more than any other nation to foster international conservation.

This strong public and private sector involvement also is evident in other international environmental areas. There is also a greater use of the abilities

and experience of the private sector in efforts to solve environmental problems that transcend national boundaries. At the international level, there has also been a greater recognition of the need to integrate environmental and economic decision-making. This emphasis was apparent in 1984 when for the first time ever environmental concerns were introduced as part of the process at the Economic Summit meeting at London in May 1984. Environmental ministers discussed the importance of harnessing the mechanisms of the market economy to help solve environmental problems. They particulary focused on the "polluter pays" principle and said that it is the key to ensuring that environmentally correct price and market signals are given.

Because U.S. participation in international environmental, natural resources, and population programs is so wide-ranging and diverse, there is a need to improve the utility of information sources on international environmental issues and to document U.S. involvement on the part of government agencies and departments, and the private sector. This collection and dissemination of information has been a major focus during 1984 of the Global Issues Working Group, which develops and coordinates Executive Branch policy on international environmental issues.

World Population Trends and Policies

The United Nations International Conference on Population (ICP) convened in Mexico City in August 1984. This occasion provided an opportunity to examine recent world population trends and to reconsider and refine United States policy regarding international population matters. Ten years earlier the nations of the world met in Bucharest, Romania, at the World Population Conference to discuss issues of population and development and to prepare a World Population Plan of Action (WPPA). At Bucharest the developed countries encouraged the developing world to establish family planning programs to help reduce the strains that rapid population growth can place on economic development. At that time relatively few developing governments had population policies or programs and many were suspicious of the emphasis the industrialized nations placed on reduction of birth rates. Many Third World countries argued instead that only a "New International Economic Order" would solve their development problems. Despite these differing views, the nations at Bucharest adopted the WPPA, which has served as a comprehensive guide for governmental, multilateral, and nongovernmental organizations in developing and implementing population policies and programs.

The scope and purpose of the U.N. ICP at Mexico City were:

- To consider progress made in implementation of the WPPA;
- To establish priority actions and goals to expedite its implementation; and
- To strengthen and sustain the momentum already generated in population activities.

The World Demographic Situation

The world demographic situation provides a backdrop for considering progress made in the implementation of the World Population Plan of Action. As

might be expected in any assessment of a plan as comprehensive as the WPPA, there is both good news and bad news to report. First and foremost, it should be recognized that looking at a world demographic situation ignores the great heterogeneity in demographic situations of the more than 200 countries and territories of the world. Many of these countries have differing population policies and programs or often no population policy at all. Likewise, many countries have made great progress in achieving the goals of the WPPA, whereas in others little progress is apparent.

A further complexity of the world demographic situation is the simplicity of the demographic equation in which population growth is the result of the balance between births and deaths. Thus, by definition, progress in the universally accepted goal of reducing deaths acts to increase population growth. As shown in Figure 11–1, although many countries have seen such progress in reducing birth rates, their simultaneous success in reducing death rates has often meant little change in population growth rates. Indeed, at the early stages of a country's demographic transition (for example, in Syria, Jordan, and Iraq), success in reducing death rates often overshadows reductions in birth rates, resulting in increasing population growth rates.

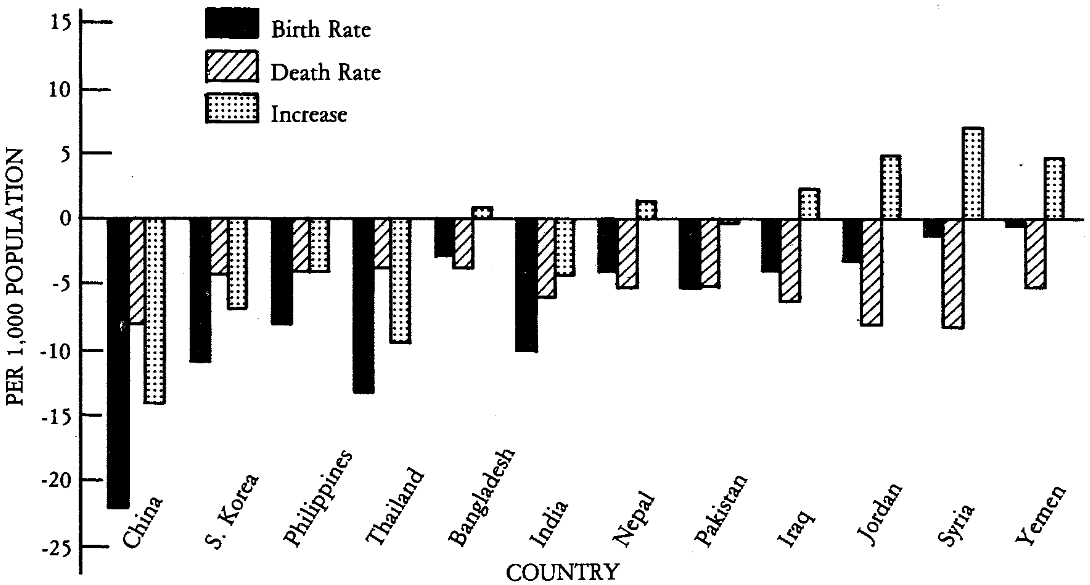
Table 11–1 shows the trends in world and regional population growth as estimated from 1950 to the present and as projected to the year 2000. On the global level, the annual rate of growth declined from 2.0 percent in the 1960s to 1.7 percent at present and is projected to decline further to 1.5 percent by the end of this century. Pessimists point out that despite the decline in the world's growth rate, the absolute number of persons added to the world's population in one year (about 80 million in both 1983 and 1984) is still larger than in previous decades. Optimists note that, in the absence of the observed drop in the growth rate, the absolute number of persons added would now be more than 100 million each year.

As Table 11–1 shows also, the regions of the world have experienced very differing trends in their population growth rates. All of the developed regions have experienced growth rate declines. Taken as a whole, the less-developed regions also have had significant declines in their growth rates, but trends differ considerably among the major regions. Latin America and Asia both show declining trends, whereas Africa thus far exhibits a continually rising rate of population growth.

Even the regional trends shown in Table 11–1 mask important differences among the countries comprising each region. The case of Asia illustrates the diversity of national situations. At the first level of disaggregation, we note that although the less-developed regions of Asia as a whole had a drop in growth rate from 2.3 percent annually (1960 to 1970 average) to 1.8 percent annually (1980 to 1985 average), if we exclude Mainland China, the remainder of less-developed Asia shows no change in growth rate between 1960–70 and 1980–85. If we disaggregate further, as done in Table 11–2, we see that the individual less-developed countries in this most populous continent (59 percent of world population) differ widely in their rates of natural increase. (The rates of natural increase shown in Table 11–2 consider only the balance between birth and death rates. The population growth rates shown in Table 11–1 also take international migration into account. For the larger countries of Asia, population growth rates and natural increase rates are usually virtually identical.)

FIGURE 11-1

CHANGES IN VITAL RATES:
1965/70 to 1980/85



SOURCE: U. S. Bureau of the Census.

TABLE 11-1 WORLD POPULATION AND AVERAGE ANNUAL RATES OF GROWTH, BY CONTINENT AND DEVELOPMENT CATEGORY: 1950 to 2000

(Population in millions and may not add to totals due to rounding)

Region	1950	1960	1970	1975	1980	1985	1990	1995	2000
	Midyear population								
World	2,549	3,035	3,703	4,082	4,451	4,845	5,258	5,702	6,152
More developed	832	945	1,049	1,096	1,136	1,174	1,208	1,238	1,263
Less developed	1,717	2,089	2,655	2,987	3,315	3,671	4,050	4,464	4,889
Africa	222	278	358	409	472	548	636	738	850
Asia	1,410	1,685	2,111	2,361	2,591	2,833	3,081	3,351	3,620
More developed	84	94	104	112	117	121	124	126	129
Less developed	1,326	1,591	2,006	2,249	2,474	2,711	2,953	3,215	3,474
Latin America	166	218	286	324	363	407	455	505	557
Northern America	166	199	226	239	252	264	277	287	297
Europe and Soviet Union	572	640	703	728	750	770	788	803	815
Oceania	12	16	19	21	23	24	26	28	30
More developed	10	13	15	17	18	19	20	21	22
Less developed	2	3	4	4	5	5	6	7	7
Excluding Mainland China									
World	1,988	2,384	2,883	3,164	3,468	3,804	4,167	4,553	4,951
Less developed	1,155	1,439	1,834	2,069	2,331	2,630	2,959	3,315	3,683
Asia	848	1,034	1,290	1,443	1,608	1,790	1,986	2,192	2,402
Less developed	764	940	1,186	1,331	1,491	1,670	1,863	2,065	2,273

Region	1950-60	1960-70	1970-75	1975-80	1980-85	1985-90	1990-95	1995-00
	Average annual rate of growth (percent)							
World	1.7	2.0	1.9	1.7	1.7	1.6	1.6	1.5
More developed	1.3	1.0	0.9	0.7	0.7	0.6	0.5	0.4
Less developed	2.0	2.4	2.4	2.1	2.0	2.0	1.9	1.8
Africa	2.2	2.5	2.7	2.9	3.0	3.0	3.0	2.8
Asia	1.8	2.3	2.2	1.9	1.8	1.7	1.7	1.5
More developed	1.2	1.0	1.3	0.9	0.7	0.5	0.4	0.4
Less developed	1.8	2.3	2.3	1.9	1.8	1.7	1.7	1.6
Latin America	2.7	2.7	2.5	2.3	2.3	2.3	2.1	2.0
Northern America	1.8	1.3	1.1	1.1	1.0	0.9	0.8	0.6
Europe and Soviet Union	1.1	0.9	0.7	0.6	0.5	0.5	0.4	0.3
Oceania	2.3	2.1	1.9	1.3	1.5	1.4	1.3	1.2
More developed	2.2	1.9	1.7	1.0	1.4	1.2	1.1	1.0
Less developed	2.3	2.7	2.5	2.4	2.0	2.0	1.9	1.6
Excluding Mainland China								
World	1.8	1.9	1.9	1.8	1.9	1.8	1.8	1.7
Less developed	2.2	2.4	2.4	2.4	2.4	2.4	2.3	2.1
Asia	2.0	2.2	2.2	2.2	2.2	2.1	2.0	1.8
Less developed	2.1	2.3	2.3	2.3	2.3	2.2	2.1	1.9

SOURCE: U. S. Bureau of the Census.

Preparations for the Second Conference

The years immediately preceding the International Conference on Population saw much preparatory activity. Four expert group meetings were convened by the United Nations to discuss technical population and related issues. In addition, the U.N.'s Regional Economic Commissions convened pre-conference regional meetings, which reviewed their respective regional population situations

TABLE 11-2. **Change in Natural Increase Rates of Asian Less-Developed Countries, 1965–70 to 1980–85 (For countries of 1 million or more population in 1965)**

Country	1965 Population (millions)	Rate of natural increase (per 1,000 population)		
		1965–70	1980–85	Change
China	728.6	25.8	11.7	–14.1
Hong Kong	3.7	18.0	12.0	–6.0
North Korea	12.1	27.6	23.1	–4.5
South Korea	28.5	21.5	14.7	–6.8
Mongolia	1.1	30.7	26.6	–4.1
Burma	24.4	22.7	25.1	+2.4
Kampuchea	6.1	24.5	25.9	+1.4
Indonesia	107.0	23.3	17.6	–5.7
Laos	2.7	25.9	25.0	–0.9
Malaysia	9.5	28.1	22.9	–5.2
Philippines	32.5	29.4	25.4	–4.0
Singapore	1.9	19.2	12.7	–6.5
Thailand	31.2	30.3	20.9	–9.4
Vietnam	37.9	22.3	21.1	–1.2
Afghanistan	11.1	22.8	22.3	–0.5
Bangladesh	58.4	26.5	27.3	+0.8
India	488.8	24.1	19.9	–4.2
Iran	24.1	32.9	30.1	–2.8
Nepal	10.3	22.0	23.3	+1.3
Pakistan	57.2	27.6	27.4	–0.2
Sri Lanka	11.2	24.0	20.3	–3.7
Democratic Yemen	1.4	23.7	28.8	+5.1
Iraq	8.0	31.9	34.2	+2.3
Jordan	2.0	31.7	36.5	+4.8
Lebanon	2.2	27.0	20.5	–6.5
Saudi Arabia	4.8	28.9	30.9	+2.0
Syria	5.3	32.3	39.2	+6.9
Yemen	4.5	22.2	26.9	+4.7
Israel	2.6	18.8	16.9	–1.9
Turkey	31.2	26.0	23.5	–2.5

Source: United Nations. 1985. *World Population Prospects: Estimates and Projections as Assessed in 1982.* New York.

and adopted recommendations that were submitted to the ICP for consideration. In spite of the diversity among the regions, the recommendations of the five regional conferences were remarkably similar. All regions reaffirmed the major tenets of the WPPA, recognized the important interrelationship between population and economic development, and restated the rights of individuals and couples to make informed decisions about childbearing.

The United Nations also convened a Preparatory Committee to review the documents prepared by the U.N. Secretariat that were to be placed before the Mexico City Conference for consideration—"The Review and Appraisal of the World Population Plan of Action" and "Recommendations for the Further Implementation of the World Population Plan of Action." The Preparatory Committee met in January and March of 1984. The "Review and Appraisal" document was examined and only slightly revised. In contrast, the comprehensive "Recommendations" document, containing 93 recommendations, was the subject of much detailed comment and controversy. The document sent to Mexico (then containing 85 recommendations) was still not considered satisfactory by many delegates. Of particular concern were references to politically controversial issues extraneous to population questions, and the rambling, all-encompassing, and frequently much too detailed content of the document. For example, although the mandate of the Mexico City Conference was to focus only on the population issues of highest priority, the "Recommendations" document touched on many contentious, unrelated, or tangential issues, such as disarmament, settlements in occupied territories, industrial health hazards, and tobacco and alcohol abuse.

In the United States, preparations for the Conference provided an occasion to articulate an international population policy that placed continued U.S. support for programs of family planning within a policy context different from that of the past. The policy was issued by the White House on July 13, 1984.[1] The policy statement included the following major points:

- Population growth is, of itself, neither good nor bad. It becomes an asset or a problem in conjunction with other factors, such as economic policy and social constraints. While many nations face critical problems associated with population pressures, we do not face a global population crisis.

- The United States reaffirms its long-standing commitment to economic and voluntary family planning assistance programs for developing nations. At the same time, it will take advantage of the experiences of the past two decades to measure the effectiveness of its economic assistance while ensuring that its family planning funds are used in ways consistent with human dignity and familial values.

- Population and economic development policies are interrelated and mutually reinforcing. Based on historical experience, the twin objectives of economic growth and population stability without compulsion will most readily be achieved through the adoption of market-oriented economic policies that encourage private investment and initiative. Such policies result in the most rapid increases and standard of living, which in turn result in a lowering of birth rates as parents opt for smaller families.

- The United States supports the primacy of the right of couples to determine the number of children they will have, and it does not accept abortion as an acceptable element of family planning programs. Accordingly, the United States will tighten existing restrictions on the use of its population assistance funds. It will no longer contribute to any nongovernmental

organization that performs or actively promotes abortion, nor will it provide family planning funds to any nation that engages in coercion to achieve its population objectives.

The International Conference on Population, Mexico City

The International Conference on Population convened in Mexico City, August 6–14, 1984. In attendance were delegations from 146 countries and 150 nongovernmental organizations, along with more than 700 journalists. Representatives of national and international organizations presented statements throughout the Plenary Session. Plenary statements confirmed wide support for the objectives of the WPPA.

The real "action" at the Conference, however, took place at the simultaneous Main Committee meeting and a number of working groups set up to arrive at a consensus on particularly thorny problems such as the "disarmament" and "settlements in occupied territories" questions or to draft the "Mexico City Declaration on Population and Development."

Although 132 amendments were offered to the "Recommendations" document, considerable agreement on the document as transmitted by the Preparatory Committee was evident. Only a relatively few countries presented the majority of the amendments, most consisting of minor changes in wording or additions. In actuality, much of the time and energy of the Conference delegates was spent on two extraneous issues—disarmament and settlements in occupied territories.[2] On population issues, there was very little disagreement among country delegates at the conference. U.S. concerns on abortion and coercion were accepted. The "Recommendations" document also recognized, at U.S. urging, that considerable progress has been made in recent decades in pursuing the objectives of the WPPA to improve the quality of life of the world's inhabitants but concluded that much remains to be done. Some statistics presented by the U.S. delegation to the Conference to illustrate the progress which had been made in pursuing the goals of the WPPA are shown in Tables 11–3 to 11–8.

Country delegates recognized that socioeconomic development is essential to achieving national population objectives and that population and development programs are mutually reinforcing. The Conference report acknowledged the fundamental rights of individuals and couples to determine without coercion the number and spacing of their children. To this end, countries agreed that family planning information, education, and means should, as a matter of urgency, be made universally available. The participating countries stated that in no case should abortion be promoted as a method of family planning.

The Conference paid particular attention to the role and status of women; governments were urged to integrate women fully into all phases of the development process. Governments and multilateral organizations were urged to increase the level of assistance or, in the case of developing countries, to allocate increased resources for population activities. Research on human reproduction and fertility regulation was targeted for particular attention. Nongovernmental organizations were urged to continue their pioneering role in the population field.

TABLE 11-3. Total Fertility Rates (TFR)[1] for World and Regions: 1950-55 and 1980-85

World and region	Total fertility rate (children per woman)		Change in number of children	Percent decline	Replacement level TFR (children per woman)[2]	Actual decline in TFR as percent of total decline (from 1950 level) required to reach replacement level fertility
	1950-55	1980-85				
World	5.0	3.6	-1.4	-28	2.1	48
More-developed	2.8	2.0	-0.8	-29	2.1	114
Less-developed	6.2	4.1	-2.1	-34	2.1	51
Africa	6.5	6.4	-0.1	-2	2.1	2
Caribbean	5.2	3.4	-1.8	-35	2.1	58
Central America	6.8	4.8	-2.0	-29	2.1	43
Temperate South America	3.5	3.2	-0.3	-9	2.1	21
Tropical South America	6.4	4.1	-2.3	-36	2.1	53
Asia	6.0	3.6	-2.4	-40	2.1	61
East Asia	5.5	2.3	-3.2	-58	2.1	94
South Asia	6.4	4.7	-1.7	-27	2.1	40

[1]The total fertility rate (TFR) is the average number of children that would be born per woman if all women lived to the end of their childbearing years, and bore children according to current fertility rates. The TFR is a refined measure of reproductive behavior which is often used to measure changes over time or differences between countries as the TFR is not affected by changes or differences in the age and sex composition of the population.

[2]Assumes mortality levels also will decline over time to the extent necessary so that 2.1 children per woman is sufficient to maintain replacement level fertility.

Source: U.S. Bureau of the Census, based on United Nations data, *World Population Prospects: Estimates and Projections as Assessed in 1982* (New York: 1985).

TABLE 11-4. Infant Mortality Rate for World and Regions: 1950-55 and 1980-85

World and region	Infant mortality rate (Infant deaths per 1,000 live births) 1950-55	1980-85	Change
World	139	81	-58
More-developed	56	17	-39
Less-developed	159	92	-67
Africa	185	115	-70
Caribbean	124	58	-66
Central America	122	57	-65
Temperate South America	83	37	-46
Tropical South America	136	70	-66
Asia	155	87	-68
East Asia	124	36	-88
South Asia	182	109	-73

Source: United Nations, *World Population Prospects: Estimates and Projections as Assessed in 1982* (New York: 1985).

TABLE 11-5. Gain in Life Expectancy at Birth, Both Sexes, for World and Regions: 1950-55 and 1980-85

World and region	Life expectancy (years) 1950-55 1950-55	1980-85 1980-85	Absolute gain (years)	Percent gain
World	45.8	58.9	+13.1	29
More-developed	65.1	73.0	+7.9	12
Less-developed	41.0	56.6	+15.6	38
Africa	37.5	49.7	+12.2	33
Caribbean	51.9	64.0	+12.1	23
Central America	49.3	65.0	+15.7	32
Temperate South America	60.3	69.0	+8.7	14
Tropical South America	49.9	62.9	+13.0	26
Asia	41.2	57.9	+16.7	41
East Asia	42.5	57.9	+25.5	60
South Asia	40.1	53.6	+13.5	34

Source: U.S. Bureau of the Census, based on United Nations data, *World Population Prospects: Estimates and Projections as Assessed in 1982.* (New York: 1985).

Issue Not Discussed in Mexico City

One issue hardly mentioned at the Mexico City Conference was the question of how the industrialized countries are dealing or plan to deal with their below-replacement fertility levels. As can be seen in Table 11-9, many European countries have seen their fertility decline to levels from which a quick

TABLE 11-6. Education Indicators in Developing Countries

Countries	Number enrolled in school as percent of age group						Adult literacy rate		
	Primary		Secondary		Higher				
	1960	1981	1960	1981	1960	1981	1960	1970	Around 1980
Low income countries	80	94	18	34	2	4	25	30	51
Middle income countries	75	102[1]	14	41	3	11	48	63	65
All developing countries	—	—	—	—	—	—	39	45	56

[1]Percent may be over 100 if children outside primary school ages are enrolled in primary school.

Sources: World Bank, *World Tables*, third edition '1983).
World Bank, *World Development Report 1984*.

TABLE 11.-7 Health- and Nutrition-Related Indicators in Developing Countries

Countries	Number of physicians per 100,000 population		Number of nursing personnel per 100,000 population		Calorie supply per capita; percentage of requirements		
	1960	1980	1960	1980	1960	1970	Around 1980
Low income countries	8.3	17.3	13.8	20.7	86.9	90.2	97.4
Middle income countries	5.8	18.5	26.1	53.0	100.3	101.1	109.5

Sources: U.S. Bureau of the Census, based on World Bank data, *World Tables*, third edition (1983), and *World Bank, World Development Report 1984*.

TABLE 11-8. Growth in Gross National Product (GNP) per Capita in Developing Countries

Countries	GNP Per Capita (1982 U.S. dollars) 1960	1982
Low income countries	145	280
Middle income countries	688	1,520

Source: World Bank, *World Development Report 1984.*

TABLE 11-9. Total Fertility Rates[1] in European Countries

Country	Average number of children per woman
Austria	1.60
Belgium	1.67 (1981)
Denmark	1.38
France	1.81
Germany, Federal Republic of	1.32
Greece	2.02 (1982)
Iceland	2.26 (1982)
Ireland	2.74
Italy	1.51 (1982)
Luxembourg	1.45
Netherlands	1.47
Norway	1.65
Portugal	2.11 (1979)
Spain	1.79
Sweden	1.62 (1982)
Switzerland	1.55 (1982)
United Kingdom	1.76

[1]The total fertility rate (TFR) is the average number of children that would be born per woman if all women lived to the end of their childbearing years and bore children according to current fertility rates. The TFR is a refined measure of reproductive behavior that is often used to measure changes over time or differences between countries, as the TFR is not affected by changes or differences in the age and sex composition of the population.

Source: Council of Europe, *Recent Demographic Developments in the Member States of the Council of Europe* (Strasbourg: 1984).

recovery to replacement level seems unlikely. Discussion of policies to deal with this situation of a potentially or actually declining population was noticeably absent at Mexico City. As Leon Tabah has pointed out, instead of discussing the question openly at the ICP, European countries took note of the problem indirectly. They discussed the problems of aging populations and the need to protect the family. These latter discussions provided a way to introduce the

idea that a rise in fertility levels may have a desirable consequence, without openly recommending a fertility policy for the industrialized nations.[3]

Broad Agreement

Despite intrusion of extraneous political issues, the Mexico City Conference displayed broad agreement among all countries on the interdependency of population programs and economic development in improving the living standards of the world's inhabitants. The major tenets of the WPPA were reaffirmed. In addition, there was heightened sensitivity to the importance of safeguards to ensure that family planning programs are truly voluntary and respect cultural and religious values. In a noteworthy change since Bucharest, the role of the private sector in providing for people's economic and social needs received much greater recognition at Mexico City. The International Conference on Population recommendations were amended to apply to nongovernmental organizations, as well as to governments. And the private sector was urged to continue its pioneering work in science, economic, and social fields.

The consensus on population and development issues expressed at Mexico City in the "Recommendations for the Further Implementation of the World Population Plan of Action" and the "Mexico City Declaration on Population and Development" will now become an official component of the system of international strategies for the promotion of economic development, the quality of life, human rights, and fundamental freedoms.

The United States and International Wildlife Conservation

> "The air was literally filled with Pigeons: the light of the noon-day was obscured as by an eclipse; the dung fell in spots, not unlike melting flakes of snow; and the continual buzz of wings had a tendency to lull my senses to repose. . . . The Pigeons were still passing in undiminished numbers and continued to do so for three days in succession. The people were all in arms. The banks of the Ohio were crowded with men and boys, incessantly shooting at the pilgrims, which there flew lower as they passed the river. Multitudes were thus destroyed. For a week or more, the population fed on no other flesh then that of Pigeons, and talked of nothing but Pigeons."

So wrote John James Audubon, the bicentenary of whose birth we celebrate in 1985, about the fall migration of passenger pigeons over the Ohio River Valley in 1813.[4] This beautiful native American bird is acknowledged to have been the most numerous bird species of all time, with a population of three to five billion, estimated by one expert to have comprised 25 to 40 percent of the entire bird population of the United States. They lived off acorns and forest nuts, not farmers' grain. During each of the 30 years leading up to 1890, an estimated 1.2 million passenger pigeons were killed for food, oil, feathers, and trapshooting. The close-packed flocks were decimated with sticks, arrows, shotguns, and nets. The disappearance of American forests also helped seal their fate. By the latter part of the nineteenth century, despite abortive localized conservation efforts, the species was in decline. With the death of the last specimen in 1914, the passenger pigeon became extinct.[5]

Another well-known species, the Carolina parakeet, died out at about the same time—captured, shot, or as a result of habitat destruction. Conservation measures have probably been too late to save the magnificent ivory-billed woodpecker; the fate of the California condor and whooping crane hang by a thread; and the bison and grizzly (in the lower 48 states) have barely survived.

That these and other extinctions or near extinctions of well-known species occurred directly or indirectly at the hand of man seems incredible in the late twentieth century, given the breadth and depth of current American concern for the preservation and well-being of wildlife. Indeed, their loss helped to generate that awareness. But their loss is not quite so incredible when one considers that the African and Asian rhinoceroses, the Asian elephant, many species of exotic birds and reptiles, and great masses of tropical-forest related plants and animals are at great risk.

Beginnings of American Conservation

When the settlers first came to America and moved across successive frontiers, the land and its resources seemed inexhaustible. We were too busy, too much in a hurry to take time to consider what we were doing to the land and its wild inhabitants. To be sure, there were glimmerings of interest, as Pennsylvania provided that one acre of trees should be preserved for every five acres cleared, and George Washington and Thomas Jefferson attempted to conserve soil, water, vegetation, and wildlife on their estates.[6] However, the first significant expression of concern was made by George Perkins Marsh, lawyer, politician, and diplomat, in his book *Man and Nature*, published in 1864 and revised in 1874. Marsh spoke from his experiences as a student of soil and geography in his own country and in Europe and the Middle East, saying:

> The ravages committed by man subvert the relations and destroy the balance which nature had established.
>
> When the forest is gone, the great reservoir of moisture stored up in its vegetable mould is evaporated.
>
> It is desirable that some large, and easily accessible region of American soil should remain as far as possible in its premature condition, at once a museum for the instruction of students, a garden for the recreation of lovers of nature and an asylum where indigenous trees . . . plants . . . beasts may dwell and perpetuate their kind.[7]

These statements foreshadowed many of the elements of American conservation concern and strategies leading into the twentieth century, as well as the direction of American involvement in international conservation. By then, the frontier was largely conquered, and Americans had time and the inclination to think about what unchecked development was doing to their natural heritage.

Earlier American conservation beginnings included the following: the setting aside and transfer to California for administration under a management plan of Yosemite Park (1864), and the creation by Act of Congress of Yellowstone as the first U.S. National Park (1872); the creation in the Department of

Agriculture of the Division of Forestry (1876), precursor of the U.S. Forest Service, and of the U.S. Biological Survey (1885), precursor of the U.S. Fish and Wildlife Service; establishment of private organizations, such as the American Forestry Association (1875), the American Ornithologists Union (1883), the precursor of the National Audubon Society (1885), the Boone and Crockett Club (1887), the Sierra Club (1892), and the New York Zoological Society (1895); and an Act of 1891 permitting the President to set aside forest reserves, and the Lacey Act of 1900 to conserve wildlife through regulation of commerce.

It was President Theodore Roosevelt and his Chief Forester Gifford Pinchot who began to advocate and pursue a unified national conservation program, based on "the use of the natural resources for the greatest good of the greatest number for the longest time" (in the words of Pinchot's associate W.H. McGee). Roosevelt regarded himself as trustee of the American people's land and dedicated millions of acres of public lands for forests, parks, and wildlife refuges.[8]

During Roosevelt's administration, the Reclamation Act of 1902 led to the creation of the Bureau of Reclamation in the Department of the Interior and major projects to reclaim vast tracts of land in western states. The national forest reserves came under the jurisdiction of the new U.S. Forest Service, headed by Pinchot, and 16 million acres of timberland were proclaimed National Forest lands before a bill restricting the President's authority to create forests in six western states became law. While Roosevelt was President, the total national forest acreage rose from 42 million to 172 million acres. Although the Inland Waterway Commission's recommendations did not become law, they served as a blueprint for future conservation action. The Antiquities Act of 1906 authorized the President to withdraw sites considered of special national or historic value: Roosevelt set aside 1.4 million acres as National Monuments under this Act. He created 51 National Wildlife Refuges. The Governors' Conference on Conservation was held at the White House, and a National Conservation Commission developed a national conservation inventory.[9]

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Subsequent milestones in United States' national conservation included: the creation of the National Park Service (1916), the Migratory Bird Treaty Act (1916), the charter of the Tennessee Valley Authority (TVA) (1933), creation of the Civilian Conservation Corps (1933), creation of the U.S. Fish and Wildlife

Service (1939–40), the Wilderness Act (1964), the Endangered Species Preservation Act (1966) (followed by the Endangered Species Conservation Act of 1969, the Endangered Species Act of 1973, and subsequent amendments), and the Marine Mammal Protection Act (1972).

American Involvement in International Conservation

The nation's concern for protection of wildlife and habitat overseas stemmed naturally from the concern for preservation in the United States. Indeed, as African leaders were to point out in the 1960s, there was an awareness that less-developed nations could learn from what had befallen major species and habitat in both Europe and the United States. Early in 1909, Theodore Roosevelt and Gifford Pinchot organized a North American Conservation Conference with Canada, Newfoundland, and Mexico, but their efforts to organize a World Conference involving 58 nations at the Hague foundered on the opposition of incoming President Taft's supporters.[10] Roosevelt, in his travels throughout the world, and Pinchot as well remained apostles of world conservation. Roosevelt notably was largely responsible for American interest in conservation of African wildlife, the last stand for most major herds of large terrestrial animals.

The impact of the loss of the passenger pigeon and other species, as well as the special appeal of birds as beautiful unfettered wildlife, generated strong support for federal control of migratory birds. A Migratory Bird Treaty with Canada was concluded in 1916 and the Migratory Bird Treaty Act, a regulatory measure based on its authority, was passed in 1918. T. Gilbert Pearson, mainspring of the National Audubon Society, led the establishment of the first major international conservation organization, the International Council for Bird Preservation (ICBP) in 1922 in London. The ICBP had significant influence on the formation of other international organizations involved in conservation, notably the organization that became the preeminent world conservation body, the International Union for Conservation of Nature and Natural Resources (IUCN).[11]

Over the years the United States helped develop and is party to: the Fur Seal Convention of 1911; the Conventions, Protocols and Agreements regulating whaling initiated in 1931; the Antarctic Treaty (1959) and related agreements; the Polar Bear Conservation Agreement of 1973; various fishery Conventions; and Conventions on Protection of Migratory Birds with Mexico (1936), Japan (1972), and the USSR (1976).

The American Committee

In 1930, Harold Coolidge, who became undoubtedly the foremost internationalist in the American conservation movement,[12] was largely instrumental in founding the American Committee for International Wild Life Protection (ACIWLP), a coalition of representatives of the most important United States private conservation organizations, including the Boone and Crockett Club, Audubon, the New York Zoological Society, the American Museum of Natural History, the Smithsonian Institution, and others. The American Committee, a private organization, played the leading role in American international conservation for the 40 years following its inception. Its objectives included:

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- "Cooperating with foreign governments and institutions working for international wildlife protection."

- "Serving as a clearinghouse and library of information on wildlife protection in all parts of the world."

- "Developing outside the United States an awareness of the importance of wildlife to all mankind for recreation as well as scientific research, and of the means for preserving wildlife in its original habitat by establishing national parks and other kinds of sanctuaries."

- "Engaging in and supporting a wide range of research and publication."

- "At the request of foreign governments, engaging well-qualified observers to investigate administrative problems of parks and nature preserves, the status of rare species, etc."

This list of objectives is taken from a history of the American Committee written by one of its vice chairman, Victor H. Cahalane, which is expected to be published by its successor organization, the American Committee for International Conservation.[13] These goals are similar and in many cases identical to the objectives of international wildlife conservation in the United States today.

The achievements of the ACIWLP, which operated on a shoestring budget of a few thousand dollars per year, as a catalyst in the field of international wildlife conservation were remarkable and varied. A principal interest was preservation of wildlife in Africa, and members of the Committee participated in the development of protection conventions and agreements; highlighted endangerment caused by tsetse fly control, poaching, legal and illegal trade; sponsored expeditions to study parks and large mammal species; and supported the establishment and maintenance of protected areas, as well as the College of African Wildlife Management (in cooperation with the American-based African Wildlife Leadership Foundation).

The highlight of similar actions vis-a-vis Asia and the Pacific was publication of seven volumes of information on the fauna and flora of the Pacific Islands, which was of vital importance for their protection during World War II. Micronesia remained an important focus of the Committee during the organization of the U.S. trusteeship and long after.

Strong Committee support led to the establishment of the Charles Darwin Foundation's Research Center and creation of parks and reserves in the Galapagos Islands in the 1930s as well as conclusion of the Convention on Nature Protection in the Western Hemisphere in 1940, eventually ratified by 11 countries, including the United States. William Vogt, a close collaborator with the ACIWLP, became chief of the Conservation Section of the Pan American Union, until the Convention became moribund in the 1950s. In the Endangered Species Act amendments of 1982, Congress directed that the Departments of the Interior and State take steps to implement the Western Hemisphere Convention and appropriated funding for that purpose to the U.S. Fish and Wildlife Service.

The American Committee played a major role in developing the endangered species data base for post-World War II international conservation efforts,[14]

sponsoring and publishing three seminal works: *Extinct and Vanishing Mammals of the Western Hemisphere* (with the marine species of all oceans) by Glover M. Allen; *Extinct and Vanishing Mammals of the Old World* by Francis Harper; and *Extinct and Vanishing Birds of the World* by James C. Greenway. Harold Coolidge pointed out, "If we could once determine those species most urgently in need of protection and at the same time find out what possible factors may have caused the destruction of species that have already vanished, we could draw up proposals for the protection of vanishing species in their natural habitat through the establishing of adequate national parks and reservations."

IUCN, the world institution now principally involved in conservation monitoring and planning, was largely an ACIWLP initiative, and IUCN's Species Survival Commission (SSC) and Commission on National Parks and Protected Areas (CNPPA) were creations of Harold Coolidge. The ACIWLP and its successor, the American Committee for International Conservation (ACIC), have been closely connected with the evolution of and American involvement in IUCN, largely funding the organization during its first two decades. The American Committee also helped plan and support the International Technical Conference on the Protection of Nature held in Lake Success, New York, in 1949 under United Nations' auspices; this meeting was to lay the foundation for international conservation activity in the 1950s.

Species of principal concern to the Committee have been the orangutan in Malaysia and Indonesia; gorillas, white rhinos, and giant sable antelopes in Africa; capybara (largest of all rodents) and vicuna in Latin America; oryx, exotic oxen, and birds of paradise in Asia and the Pacific; whales, fur seals, marine turtles, and polar bears. With regard to protected areas, the Committee published *National Parks, A World Need* and helped organize the First World Conference on National Parks in Seattle in 1962 (with Coolidge as chairman).

The active role of ACIWCP as a major catalyst for international wildlife conservation came to an end in the late 1960s as the organizations that composed the Committee became more and more involved with their own expanding international programs. Its successor, the ACIC, organized in 1975, has concentrated on serving as U.S. national committee for the IUCN, monitoring the conservation impact of U.S. activities overseas and coordinating, as appropriate, international conservation activities of its component organizations. The American Committee was commended by President Gerald Ford in 1976 for its "record of outstanding achievement."[15]

The Washington Conference

One of the most significant international conservation developments was the conclusion of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), at a major international conference in Washington, D.C., February–March 1973, a joint achievement of the United States government, a number of other key countries, such as Kenya, nongovernmental organizations, and IUCN.

Concern about the impact of international trade on wildlife began in the early years of this century. In 1911 at the urging of organizations such as the National Association of Audubon Societies and prominent conservationists, New York State had passed the Audubon Plumage Bill, outlawing the sale of plumes

of all native American birds, and the Bayne Bill, banning the sale of native wild game.[16] The Federal Tariff Act of 1913 prohibited import of feathers or parts of wild birds.[17] The Tariff Act of 1930 banned import of any wild mammal, bird, or part or product thereof taken or exported in violation of foreign law, and the Lacey Act amendment of 1935 extended this control to any type of wildlife.[18]

By the 1950s, IUCN and its Species Survival Commission (SSC) had identified trade as a major increasing threat to populations of certain species; the 1960 IUCN General Assembly declared that "a major threat to the existence of some rare animals is their illegal exportation from the country of origin, followed by their legal importation into other countries."[19]

At the 1961 Arusha Conference to assess future conservation needs on the African continent, members of the United States delegation stimulated a proposal for an international convention to control trade in endangered species; a resolution at the 1963 IUCN Assembly in Nairobi called on IUCN to prepare the draft. The U.S. Endangered Species Conservation Act of 1969 (supplementing the Endangered Species Preservation Act of 1966) authorized the Secretary of the Interior to promulgate a list of species "threatened with worldwide extinction," to prohibit importation (except for certain limited purposes) and directed the Departments of State and the Interior to seek a meeting to reach agreement on an international convention.[20] Concerned individuals within the Council on Environmental Quality (Chairman Russell Train and Senior Scientist Lee Talbot), staff of the New York Zoological Society, Harold Coolidge as President of the IUCN, and other Americans played a leading role in developing and tightening drafts for the convention and arranging for the conference to be held in Washington. The 1973 meeting attracted significant American public attention and interest.[21]

The carefully prepared mechanism that emerged as CITES became a central focus of world conservation. It prohibited commercial trade by its Parties in species threatened with extinction, controlled trade (through permits) in those that might become threatened unless commerce in them was strictly regulated, provided for a Secretariat and biennial Conference of Parties and for direct communication between Management Authorities and Scientific Authorities of Parties. As of the end of 1984, CITES had 87 national Parties and is at the center of American governmental and nongovernmental conservation activities.

1984: Taking Stock

By 1984, the United States was extensively involved in many phases of international wildlife conservation. Two reports, prepared for the United Nations Environment Program (UNEP) and for the United States Congress, reviewed the wide-ranging and multifaceted American public and private activity in this field.

U.S. Activities Related to Conservation of Genetic Diversity

In May 1983, UNEP's Governing Council requested Executive Director Mostafa Tolba, in cooperation with governments and relevant intergovernmental organizations, to continue to promote the *in situ* conservation of endangered

animal and plant genetic resources. Tolba, in turn, requested UNEP member states to provide information on current and planned activities in the field. The lengthy United States response, distributed in March 1984 by the Department of State, attempted to summarize both governmental and nongovernmental efforts vis-a-vis genetic resources, as well as the broader effort to conserve biological diversity in general.[22] Conservation of wildlife resources is a major element of the conservation of genetic resources.

Federal activities discussed in the report, which have an important impact on *international* wildlife conservation, include:

- The Endangered Species Program, administered by the U.S. Fish and Wildlife Service (FWS) of the Department of the Interior and the National Marine Fisheries Service (NMFS) of the Department of Commerce, lists and provides protection for foreign species and a mechanism to assist protection programs in other countries.

- United States participation in, compliance with, and leadership in the 87–nation Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) helps to protect wild animal and plant species against overexploitation through international trade.

- The FWS, NMFS, the National Park Service, and others are further involved in efforts directed at international wildlife conservation, through the Convention on Nature Protection and Wildife Preservation in the Western Hemisphere; international conventions related to fish, whales, seals, and polar bears; use of U.S.-owned foreign currencies in Egypt, India, and Pakistan; cooperative efforts with our closest neighbors, Canada and Mexico, as well as bilateral arrangements with many other countries.

- The United States participates actively in the Man and the Biosphere (MAB) Program of UNESCO through internationally oriented research and participation (with over 40 units) in Biosphere Reserves, established for the conservation of representative natural areas and the genetic and biological material they contain.

- The Smithsonian Institution, through its Botanical Department and the Tropical Research Institute in Panama, is engaged in major investigative and research activities related to endangered plant species, especially in Latin America; while the National Zoological Park works toward reintroduction of species into their natural environment.

- The National Science Foundation awards grants for research in tropical biology.

- Agencies involved in foreign assistance to developing countries, such as the Treasury Department, with regard to Multilateral Development Banks, and the U.S. Agency for International Development (AID) have incorporated concern for conservation in their policies and programs. AID finances assistance to less developed countries for biological research, species

inventories, development of environmental and conservation guidelines, training of wildlife managers, and establishment of natural reserves.

- The Peace Corps works closely with AID, the U.S. Forest Service, the National Park Service, and other U.S. agencies in assisting in conservation of tropical forests, wildlife, etc. in developing countries.

The report also noted the impetus for U.S. policy in conservation emerging from the November 1981 "U.S. Strategy Conference on Biological Diversity," organized by the Department of State, AID, CEQ, and six other federal departments and agencies. The conference evaluated the scope and magnitude of biological diversity issues, examined U.S. interests involved, emphasized the vital world need to preserve diversity, and recommended, *interalia*, establishment of an interagency task force to review current programs and develop comprehensive long-term U.S. goals and strategies. CEQ's Global Issues Working Group, involving 17 federal departments, agencies, and bureaus, identified biological diversity/genetic resources as one of 20 areas of focus.

The United States' report to UNEP also outlined *nongovernmental* participation in the *in situ* conservation of genetic and biological resources. Some of the organizations cited as working in international conservation are the following:

- World Wildlife Fund-U.S., affiliated with World Wildlife Fund-International and sister appeals in 23 other countries, is involved in major international wildlife conservation projects, including a 20-year study to determine the minimum critical size required to maintain threatened tropical forest species; protecting vulnerable primates and other animals; establishing, planning, and maintaining protected areas, including migratoty species habitat and migration routes; and preventing overexploitation of species through international trade.

- The Nature Conservancy, with worldwide *in situ* preservation of natural diversity as its principal mission, assists indigenous institutions in Latin America to carry out their own conservancy programs.

- The National Audubon Society publicizes and promotes citizen concern and action to protect both domestic and international wildlife species and is involved in research and international protection projects for species of the Caribbean and Mexico.

- The New York Zoological Society's (NYZS) Wildlife Conservation International division seeks to apply a better understanding of large ecosystems to conserving them and their endangered animal and plant resources. It has participated in the development of nearly 50 reserves outside the United States and has more than 50 international projects relating to species and their habitat. The NYZS Wildlife Survival Center also promotes conservation through reintroduction of endangered species, as do other members of the American Association of Zoological Parks and Aquariums (AAZPA).

- The U.S.-based African Wildlife Foundation promotes conservation of African wildlife through support for training, public education and awareness programs, anti-poaching efforts, research, provision of equipment, and coordination.

- Organizations such as the Sierra Club, the Environmental Defense Fund (EDF), and the Center for Environmental Education (CEE) work to encourage conservation through the development of public awareness, education, and advocacy. Sierra's International Earthcare Center concentrates on creation and preservation of reserves, while CEE focuses on protection of oceans and marine life, especially whales, seals, and sea turtles. EDF's wildlife program is directed at the preservation of biological diversity in natural ecosystems, with high priority assigned to protection of endangered animals, plants, and habitats.

Private research activities related to international conservation cover a wide range:

- The Board on Science and Technology for International Development of the National Academy of Science's National Research Council publishes assessments of unconventional tropical animal and plant resources and technologies that might be especially useful to preserve and promote in developing countries.

- The International Institute for Environment and Development, in conjunction with IUCN, and with the support of AID and other development agencies, provides assistance to developing countries in establishing National Conservation Strategies.

- The World Resources Institute has a two-year biological diversity project to examine the dimension, meaning, causes, and ways of alleviating habitat and species loss.

- The Wildland Management Center of the University of Michigan is conducting interdisciplinary integration of research, instruction, and field activities to address the protection and use of wild species and natural ecosystems on a sustainable basis.

- Botanical organizations, e.g., the Missouri Botanical Garden and Harvard's Arnold Arboretum, conduct research related to conservation in the Latin American, African, and Southeast Asian tropics.

- Groups such as those of Native Seeds/SEARCH, based in Tucson, Arizona, which works closely with American and Mexican Indian farmers to discover and enhance rare plants.

Conserving International Wildlife Resources: The United States Response

The International Environment Protection Act of 1983 mandated a review of

the effectiveness of existing United States international activities relating to the conservation of international wildlife resources, with recommendations to improve substantially existing capabilities. The resulting report, transmitted to the Senate Foreign Relations Committee and House Foreign Affairs Committee in December 1984, was also prepared by the Department of State, in conjunction with the National Park Service and the U.S. Fish and Wildlife Service of the Department of the Interior.[23]

For purposes of the report, international wildlife resources were defined to include both animal and plant species as well as the habitat upon which they depend. The report provided a compendium of current federal agency responsibilities and programs set forth on a functional basis as called for explicitly in the legislation, and concluded that the U.S. Fish and Wildlife Service, the National Park Service, the Department of State, the Agency for International Development and the Smithsonian Institution are the most directly and intensely active. To a lesser but important degree, the Departments of Justice and the Treasury, the Peace Corps, the U.S. Forest Service and the National Marine Fisheries Service also focus on various elements of international wildlife conservation.

The report also reviewed the range of mechanisms available to the United States government to advance wildlife policy objectives: domestic programs, which enable the U.S. to demonstrate and lead by example; bilateral cooperation; our influence in multilateral organizations; and stimulation of and cooperation with the private sector. Through these mechanisms, the U.S. carries out a broad-based effort at the international level, including: research and monitoring; development and exchange of data and information; demonstration and management programs involving wildlife populations and habitats; enforcement of treaty obligations and wildlife laws (both domestic and foreign); technical assistance; institution-building through training and education; and direct financial support for foreign conservation through a variety of collaborative vehicles.

The State/Interior report concluded with an integrated U.S. action plan for conservation of international wildlife resources, which incorporated recommendations to increase capabilities of various federal agencies, as requested in the legislation. Elements of the plan include: clarification and strengthening of U.S. government authority, policy, and organization for international conservation efforts; improvements in collection and exchange of information; improved coordination among federal agencies, and between them and the private and international sector; better coordination and possible enhancement of research and monitoring; systematic use of available information, especially in reviewing development projects that may impact on wildlife resources; more effective assistance to foreign conservation, melded and coordinated with the private and international sectors; and development of knowledge, capabilities, and awareness in wildlife resource countries through training and public education.

Other United States Activities in 1984

In the International Environment Protection Act of 1983, Congress also determined that wildlife protection should be an important objective of United States

development assistance, authorized the furnishing of such international assistance in protecting habitats and in developing sound wildlife management and plant conservation programs, and mandated the formulation of a U.S. strategy to conserve biological diversity in developing countries. The strategy was devised during 1984 by a task force chaired by the Agency for International Development (AID), in conjunction with other agencies and in parallel with the wildlife resources conservation report; it was published in February 1985.

Continuing the focus on conservation of wildlife endangered through international trade, the U.S. took a leadership role in meetings of the CITES Standing Committee and Technical Committee in 1984 and assisted the CITES Secretariat in an October seminar in Kuala Lumpur, Malaysia, on implementation of the Convention for Asian and Oceanian parties. The United States chaired the first meeting of the Plant Working Group of the CITES Technical Committee in Tucson, Arizona, in Febuary-March 1984, and a U.S. representative played the lead role, working with the CITES Secretariat and members of the Standing Committee in devising a more effective and appropriate relationship between CITES, the United Nations Environment Programme (UNEP), and the International Union for Conservation of Nature and Natural Resources (IUCN). Until November 1984, IUCN had administered the Secretariat on behalf of UNEP; it is now administered by UNEP directly, with IUCN providing scientific support, trade data, etc.

Enhanced State Department Efforts

The Department of State is playing an increased facilitative role in providing U.S. wildlife enforcement agencies (i.e., the U.S. Fish and Wildlife Service and the Department of Justice) with an improved channel of communication for obtaining information and evidence abroad for potential United States criminal or civil actions. In mid-1984, in recognition of the foreign relations implications of international conservation efforts, the Department began to develop a program that was both more activist and catalytic and that viewed enforcement of U.S. wildlife laws and international agreements as a major component of American international conservation efforts and one of the most cost-effective and productive. The Department has informed all U.S. Ambassadors of its view of the importance of U.S. conservation efforts and the potential role of the U.S. Foreign Service in these efforts and has provided background information on present and emerging wildlife issues for embassies. The interagency cooperative effort is coming to fruition, with prosecution of illicit traffickers of wildlife pending before U.S. Courts in Denver, Los Angeles, Miami, and Seattle at the present time.

AID Issues Landmark Tropical Forest Policy

In November 1984 the Agency for International Development (AID) issued highly significant policy and program guidance to all its missions, recognizing "the unique role and special environmental characteristics of humid tropical forests." The message supplemented earlier policy determinations and strategy papers related to the environment, natural resources, and forestry. It noted that "humid tropical forests are unique ecosystems essential to the survival of vast

numbers of species of plants and animals both within the forest areas themselves and throughout the rest of the world" and pointed out the significant interrelationship between these forests and soil, water, and global climatic systems. It stressed the great biological diversity contained in tropical forests and the immense reservoir of genetic diversity. AID stated that it is "general policy to exercise extreme caution in pursuing development projects which lead to the full or partial conversion of the forests" and that the development of programs affecting these types of forests should be approached from the perspective that a top priority is conservation and sustainable management of their unique resources.

AID expressed its intention to make a concerted effort to increase the awareness of other U.S. government agencies and other donors, both bilateral and multilateral, and its willingness to support efforts to increase awareness in host countries, preserve and manage humid tropical forests, establish protected reserves, identify and implement alternatives to deforestation, and conduct research and training.

Looking Ahead

The current foci of the nation's efforts in international wildlife conservation are wide and varied. At this moment, the United States is undoubtedly doing more than any other nation, through its public and private programs, to foster and contribute to conservation efforts at the international level. However, it is clear from the reviews undertaken in 1984 and from other studies, such as the World Conservation Strategy (produced by IUCN in cooperation with UNEP and World Wildlife Fund), that there is both good news and bad news to report. The numbers of species that have shown significant signs of recovery at least partially as a result of international conservation efforts, such as the American alligator, the Nile crocodile, spotted cats (e.g., the leopard and cheetah), and endangered raptors like the peregrine falcon, are encouraging and significant; but the risk to many species and habitats remains high.

The story of the recovery of the American alligator provides a dramatic contrast to the fate of the passenger pigeon and points the way for success with at least some other species under threat of extinction. This large reptile is only one of the two surviving species of the genus *Alligator*; it evolved some 180–200 million years ago and shows many advanced characteristics, such as a four-chambered heart, a rudimentary diaphragm, and elaborate maternal behavior.

Commercial demand for alligator hide in the 1950s and 1960s led to overharvest and alarming population decline. The American alligator was first classified as "endangered" in 1967. In 1969 an amendment to the Lacey Act prohibited interstate commerce in illegally taken reptiles and their parts and products, helping to reinforce state laws, and the Endangered Species Act of 1973 added heavy penalties. Finally, the American alligator was listed on Appendix I of the Convention on International Trade in Endangered Species when the Convention was concluded in 1973, precluding commercial trade between CITES parties.

These legal mechanisms, effective federal and state management, and law enforcement resulted in the rapid partial or complete recovery of many alligator populations. The American alligator could be reclassified from "endangered"

to "threatened" in several areas of the southeastern United States in the 1975–1985 decade. However, the U.S. Fish and Wildlife Service maintains restrictions on commercial activity involving alligators through a "special rule," because of the similarity of the American alligator to other, more endangered crocodilians.[24] The species was transferred from CITES Appendix I to Appendix II in 1979, and American alligator skins could again be traded on a restricted basis internationally.

Examples of current wildlife issues of international concern include: (1) Major trafficking in endangered species and products, such as exotic birds, rhinoceros horn, elephant ivory, reptile leather, and cacti; (2) the preservation of migratory birds that range from the far North to the developing, environmentally threatened tropics, as well as herds of migratory caribou that move between oil-rich Alaska and Canada; (3) protection of threatened ecosystems that support major concentrations of wild species, such as the Serengeti-Mara of Tanzania and Kenya and the coral reefs of the Caribbean; (4) conservation of representative biosphere reserves and natural sites of world significance; (5) maintenance of regional wildlife management and conservation training institutions, such as the College of African Wildlife at Mweka, Tanzania; (6) research into the minimal critical size of ecosystems needed to sustain plant and animal populations, which is currently taking place in Brazil. These are only a few of the many conservation issues confronting the United States in the world community.

Interagency consideration of the recommendations in the International Wildlife Resources Conservation report submitted to Congress concluded that it is important to move forward with implementation, and that closer linkages and coordination need to be forged between agencies, and with them and the private sector to achieve more effective use of limited resources. The history of the American Committee for International Wild Life Protection (ACIWLP) demonstrates the potential of the private sector, and the United States role in CITES provides a model for effective international involvement.

There is general agreement that a more coherent United States policy focus to direct efforts toward international wildlife resource conservation is needed, both for the government as a whole and within action agencies. While information on the status of species and habitats, wildlife laws, conservation projects and needs exists, it is not necessarily accessible to those who need it; thus devising an effective inventory is highly important. Enforcement and other wildlife conservation action should be closely coordinated through a working-level interagency committee, possibly complemented by a policy level committee.

The interagency review also concluded that more can be done to use international conventions as vehicles for U.S. support of international wildlife conservation, as is already the case with CITES. The Administration is developing a request to Congress for advice and consent to United States ratification of the Convention on Wetlands of International Importance Especially as Waterfowl Habitat (Ramsar Convention), which can serve as a valuable mechanism for providing and exchanging technical and other assistance to countries, especially those south of the border with wetlands used by our migratory birds.

The recent past has demonstrated increasing consciousness on the part of Americans concerning the environment and conservation, on both a national and international level. For the United States to extend its efforts, those

countries that provide the habitat for wildlife overseas must also become conscious of the desirability and need for conservation. It seems clear that this international consciousness is growing, and the United States will have a continuing, important role to play.

U.S. Industry and the International Environment

In 1984 the U.S. government intensified efforts to involve U.S. industry more actively in international environmental matters. In particular, U.S. industry and government worked together to develop the joint position presented on behalf of the United States at the World Industry Conference on Environmental Management (WICEM), which took place in November 1984 under the joint sponsorship of the International Chamber of Commerce (ICC) and the United Nations Environment Programme (UNEP). WICEM involved hundreds of representatives from industry, particularly multinationals, and from governments. U.S. participation demonstrated the nation's private and public sector cooperation and joint achievements in the environmental field.

These industry-related developments were mirrored in discussions that took place within the framework of the Economic Summits. At the London Economic Summit in May 1984, the Heads of State had "recognized the international dimension of environmental problems and the role of environmental factors in economic development" and had "invited Ministers responsible for environmental policies to identify areas for continuing cooperation in this field." This led directly to a meeting of the Summit Nations Environment Ministers in London on December 17, 1984, where they affirmed their countries' collective commitment to the following: (1) that environmental policy should be integrated fully into other policies; (2) that environmental protection should be considered as a fundamental factor when economic decisions are taken; and (3) that expanded international cooperation, with private sector participation, is required to address a range of emerging and critical international problems associated with industrial development, including the transfer of hazardous chemicals or the siting of facilities in developing countries.

The Environment Ministers of the United States, Canada, the Federal Republic of Germany, Italy, Japan, and the United Kingdom reviewed the issue of better government and industry cooperation, particularly in developed nations, and concluded that

> "The tragedy in India, which occurred only a few days before our meeting, emphasized the problems that can attend the transfer of technology or of hazardous chemicals to developing countries. We are clear that this must be an area for continuing cooperation among our own and other industrialized nations in consultation with developing countries, and we welcome action being taken by OECD to draw up possible guidelines. One suggestion is that there might be jointly agreed government-industry monitoring teams to assess such operations. Further study and discussion are required, but we are clear that our efforts must be directed toward reinforcing the cooperation between developed and developing nations to mutual benefit of both."

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In another development of note in 1984, the Organization for Economic Cooperation and Development (OECD) adopted a "recommendation" regarding information exchange on banned or severely restricted chemicals. OECD Member States are recommended to provide information related to the export of chemicals that are banned or severely restricted in the country of export, in accordance with certain guiding principles that are attached to and made integral to the basic recommendation.

These integral guiding principles indicate that importing States have the primary responsibility for protection of health and environment from risks associated with imports of chemicals that have been banned or severely restricted in exporting countries. The principles also make the point that the exporting Member States should take steps to assist importing countries in reaching appropriate decisions with respect to such imports.

Another achievement in the important information exchange field was the adoption by the UNEP Governing Council in May 1984 of a Provisional Notification Scheme on Banned or Severely Restricted Chemicals. The Provisional Notification Scheme was developed using the OECD Recommendation and Guiding Principles as a model. Participating countries are now in the process of implementing the Scheme and soon will start to accumulate experience with its use. A further review of the Scheme within UNEP is anticipated in 1986–1987. Both the OECD and UNEP information exchange arrangements are generally consistent with U.S. domestic law that pre-dated these international efforts.

World Industry Conference on Environmental Management

The World Industry Conference on Environmental Management (WICEM), held November 14–16 at Versailles, France, took important steps toward an improved dialogue and spirit of cooperation between industry and governments on environmental issues at the international level. The United States government is now working with U.S. industry, the International Chamber of Commerce (ICC), and the United Nations Environment Programme (UNEP) to build on this foundation.

The 480 conference delegates from 69 countries included representatives of industry, labor, governments, science, intergovernmental bodies, and nongovernmental environmental organizations. Assistant Secretary of State James Malone joined EPA Administrator William D. Ruckelshaus and his Associate Administrator for International Activities, Fitzhugh Green, as U.S. Executive Branch representatives. Senator Claiborne Pell represented the Congress. Other American participants included David Roderick, Chairman of U.S. Steel, who served as a Conference convenor along with Administrator Ruckelshaus, and a number of chief executive officers (CEOs) of other prominent U.S. firms.

The WICEM was the direct outgrowth of a 1982 U.S. initiative in the UNEP Governing Council calling for greater use of the abilities and experience of the private sector in efforts to solve international environmental problems. A U.S. Steering Group, made up in large part of leaders of U.S. industry, for example, Tenneco, U.S. Steel, the Continental Group, and Alcoa, had a major role in preparations for the Conference. UNEP's sponsorship of the conference and its involvement in the predominantly U.S.-led preparatory activity represent its first major initiative to engage private business and industry in implementing

its environmental mandate. The conference, which has laid a foundation for significant future progress, took up three major subjects: (1) industry's experience with environmental problem-solving; (2) environmental management opportunities and constraints; and (3) more effective environmental management. It also considered followup processes for cooperation and collaboration. The introduction to the WICEM Final Declaration embodied the main theme of the conference: that the time of confrontation over environmental matters is past and that all parties concerned should work together toward meeting the common responsibility to protect the environment.

The Declaration set forth five major principles:

1. Sustainable economic development is an essential international goal, and environmental management is an integral part of that development;
2. Economic growth can be made compatible with environmental protection;
3. Despite its limitations, cost/benefit analysis is an essential element of environmental decision-making;
4. Besides the direct cost of environmental protection, the cost of damage to society as a whole must be considered; and
5. A preventive approach is preferable to correcting environmental problems after they have occurred.

Among the Declaration's 14 specific recommendations were:

1. Greater industry participation in international environmental management policy-making;
2. Additional financial help to developing countries to enhance their capabilities for environmental management and resource protection;
3. Participation by multinational companies in local environmental protection efforts; and
4. Accelerated establishment of international environmental impact principles and guidelines.

Recommended followup activities included consultations by the ICC with industry CEOs and by UNEP with governments to implement the recommendations for "government-UN-industry" partnerships in managing the environment, with emphasis on assistance to developing countries.

Following WICEM, the U.S. Steering Group met again in December 1984 in New York City to assess WICEM's results and to plan for the future. Optimistic as a result of the initial success of WICEM, the group is looking to UNEP and ICC as vehicles for demonstrating the strengthening of environmental concerns of world industry generally and of U.S. industry in particular. A high-level meeting of industry and government representatives, under joint ICC and UNEP auspices, is planned for November 1985 to develop recommendations for further WICEM follow-up activities.

Environment in the Economic Summit Disccussions

Environmental concerns were introduced for the first time in the Economic Summit process at London in May 1984. At that time the Heads of State final communique called for: (1) the Environment Ministers of the seven Summit countries and the European Community to evaluate emerging issues and opportunities for future cooperation; and (2) a report to be prepared on environmental research priorities. This gave rise to a special meeting of the Summit

countries' Environment Ministers or their representatives in London on December 17, and preparation of a report on environmental research by the Summit Working Group on Technology, Growth and Employment. The report, completed in December, was forwarded to the Heads of State for consideration at their May 2–4, 1985 meeting in Bonn, and was scheduled for subsequent public release.

The meeting of ministers and their representatives focused attention on the crucial factors in national policies and identified specific environmental problems where expanded international cooperation is necessary. The participants encouraged conducting the needed cooperation in existing institutions rather than creating new organizations or bodies.

The ministerial meeting discussed the need to integrate environmental and economic decision-making. Discussion stressed the importance of sustainable development, the need to prevent rather than cure pollution problems, the conducting of environmental impact assessments and the development of environmental standards based on best technology, and the development of less-polluting and more cost-effective technologies. It called for harnessing the mechanisms of the market economy and the forces of competition to help solve environmental problems and stated that the "polluter pays" principle is the key to ensuring that environmentally correct price and market signals are given.

Participants pointed to OECD as the primary instrument for intensified cooperation on environmental and economic matters and noted that the organization's Environment Committee was meeting at the ministerial level in June 1985 to consider future international cooperation. The ministerial session identified a number of environmental problem areas where international cooperation was needed. These included stratospheric ozone depletion, acid deposition, carbon dioxide and climate, and the management of toxic chemicals and hazardous wastes. Other areas identified were fresh water and marine pollution, resource conservation, alternative energy strategies, and biotechnology.

As the meeting took place in the shadow of the tragic Bhopal, India, chemical incident, the ministerial meeting agreed that the Summit countries should devote special attention to environmental problems in developing countries. There was general agreement that Summit governments needed to work with developing countries to help achieve sustainable development and avoid environmental degradation. The participants also welcomed the establishment of the World Commission on Environment and Development (WCED) by the U.N. General Assembly in December 1983 as an independent body to report in 1987 on likely global environmental conditions and requisite responses in the year 2000 and beyond.

The Economic Summit Working Group on Technology, Growth and Employment met three times under the direction of the United Kingdom to prepare a comprehensive report on international environmental problems and research needs. Completed in December 1984, the report presents an overview of environment, development, and science and technology relationships, including six technical annexes discussing international cooperation in atmospheric pollution, toxic and radioactive wastes, marine pollution, soil and water degradation, land husbandry problems, and climate change. The report provides a comprehensive and detailed overview of contemporary international environmental research needs and priorities in public policy, education, and public information.

The Interagency Global Issues Working Group

The interagency Global Issues Working Group (GIWG) was formed in 1981 to coordinate Executive Branch policy on pressing global problems of environment, population, and resources. The GIWG is headed by the Chairman of the Council on Environmental Quality, with participation from the other Executive Branch agencies that are responsible for environmental policy regulation and/or implementation.

The first major activity of the Working Group was to develop a set of eight international environmental principles, which were put forward in the U.S. plenary address to the United Nations Environment Programme Session of a Special Character in Nairobi in 1982. These principles still provide the most current presentation of the overall U.S. approach to international environmental matters.

1984 Activities

During 1984, in addition to work by member agencies on international environmental issue papers and coordination of input from member agencies to international organizations, such as the United Nations Environment Programme (UNEP), Organization for Economic Cooperation and Development (OECD), and Economic Commission for Europe (ECE), the GIWG was substantially responsible for the three publications described below.

Corporate Use of Environmental Information

A report on "Corporate Use of Information Regarding Natural Resources and Environmental Quality" was completed in May 1984 by the World Wildlife Fund (WWF) for the Council on Environmental Quality.[25] This report had as its purposes: (1) to identify corporate needs for resource information; (2) to assess the extent to which these needs are being met by various resource information services, including those of the federal government; and (3) to recommend improvements to the federal government's resource-information services.

The report presents findings and recommendations from a one-year study of the corporate use of information regarding natural resources and environmental quality, as noted below:

- U.S. corporations urgently need more international data;
- U.S. corporations feel that the government's natural resource forecasts are not credible;
- U.S. corporations need upgraded and expanded data on environmental quality;
- U.S. corporations believe that government information is not timely;
- Information on natural resources and environmental quality is vital to the success of U.S. corporations;
- U.S. corporations depend on a large body of this information in making decisions regarding capacity, siting, marketing, production, and strategic planning, among others; and
- The U.S. government is the principal source of information on natural resources and environmental quality.

To improve the network of information sources available to U.S. corporations and to promote better decision-making, the report recommended the following:

- The establishment of a clearinghouse for international natural resource information;
- An improvement in the credibility of government natural resource forecasts;
- The collection of more and better data regarding environmental quality;
- An improvement in the timeliness of government information;
- The creation of an index of government natural resource and environmental quality information; and
- A strengthening of federal statistical policy management.

These recommendations reflect the information needs identified as most pressing by corporate personnel.

Improving Access to U.S. Government Environmental Information

A reference manual was published in November 1984 (as a followup to the first recommendation of the WWF report), titled "Gaining Access to U.S. Government Information on the Environment and Natural Resources" by the U.S. Department of Energy and the Council on Environmental Quality.[26] This publication is designed to acquaint the reader with the broad range of services and publications that are offered by the U.S. government and that provide information about the environment and natural resources. These sources of information include referral services, public information offices, computerized data banks, information-analysis centers, and publiciation-distribution systems, as well as published sources such as bibliographies, abstract and index journals, reports, handbooks, and atlases.

The subject matter covered by this sourcebook includes air pollution, meteorology, water resources and quality, fisheries, aquaculture, marine science, solid and hazardous waste treatment, land use, soil science, population and demography, anthropology, architecture, geography, urban studies, health, biology, agriculture, forestry, habitat, wildlife, geology, minerals, and related sciences and technologies.

The different types of literature in which information about the environment and natural resources is published are identified and described. The structure of and interrelationships within this literature are then discussed to allow the reader to determine what genre of publication might best serve his or her information needs. Many information services of the relevant U.S. government organizations are reviewed and a brief description and analysis of each service is provided. These descriptions are grouped by government organization, and each group is prefaced by a brief description of the concerns and activities of that organization related to the environment or to natural resources.

A bibliography is also presented, which lists and describes data bases, abstract and index journals, recent bibliographies, reviews, handbooks, manuals, catalogs, directories, atlases, dictionaries, encyclopedias, and other types of publications that can help the reader find environmental and natural resources data and information. It is organized by subject, and within subject by type of publication.

U.S. Government Participation in International Environmental Agreements

An updated inventory was prepared by the Department of State for the Global Issues Working Group, titled "U.S. Government Participation in International Treaties, Agreements, Organizations, and Programs in the Fields of Environment, Natural Resources and Population."[27] This inventory represents the second edition of a comprehensive overview of current U.S. government international (bilateral and multilateral) commitments in the environment-resources-population area.

The document covers federal agency participation in: multinational treaties and conventions; bilateral treaties and agreements; and programs of major international and regional organizations.

The substantive areas subsumed in the inventory are: (1) Population and Human Settlements, including Family Planning, Biomedical Research, Human Settlements, and Environmental Health; (2) Resources, covering Food (Agriculture, Crops), Arid Lands, Forests, Wetlands/Coastal Zone, Wildlife and Natural Habitat, Water Resources (Surface; Underground), Ocean Resources (Non-Living; Living), Non-Fuel Minerals, and Energy; and (3) Environment, which covers Air Quality (Lower and Upper Atmosphere), Water Quality (including Drinking Water and Sanitation), Marine Pollution, Toxic Substances/Pesticides/Hazardous Wastes, Energy-Environment Relationships, Solid Waste, Noise, and Environmental Assessment.

The inventory lacked detailed information on program content and funding, but included a number of interpretive observations:

1. U.S. government support for and participation in international environmental resources and population programs is extremely wide-ranging and diverse. The U.S. is party to 26 major international conventions and treaties; cooperates with 73 foreign nations through some 265 separate bilateral treaties and agreements (some of a general government-to-government nature and most of a subject matter-specific agency-to-agency variety); and participates in over 70 specific programs carried out by some 40 international and regional organizations, commissions, and councils.
2. The range of subject matter involvement is equally broad and diverse, with the focus of our international treaty and convention commitments on marine resources, marine pollution, and wildlife; and the emphasis of our international program participation at the moment largely on air quality, toxic substances, agriculture, and environmental monitoring and assessment.
3. The U.S. government cooperates on a bilateral basis with nations in all major regions of the world. In terms of numbers and scope of bilateral agreements, the current U.S. emphasis is on cooperation with our immediate neighbors, Canada and Mexico; although agreements are also made with the Federal Republic of Germany, Japan, China, the Soviet Union, India, Saudi Arabia, and Poland.
4. Besides the "internationally-focused" agencies — the State Department, AID, and the Peace Corps — the Departments of Agriculture, Commerce, Interior, and the Environmental Protection Agency report the largest number of international treaty and program involvements. Interpreting the character and overall magnitude of these international commitments would require supplementary information.

1985 Agenda

During 1985, CEQ and the GIWG jointly and separately have planned a number of activities to implement the recommendations of the World Wildlife Fund report. In March a CEQ-sponsored report on "Long-Term Environmental Research and Development" was published, which arose from some of the same concerns that prompted the WWF report, and which has a number of recommendations that address in part the WWF report recommendations. For example, the long-term research report recommends "that CEQ foster an evaluation by an appropriate organization of existing physical, chemical, and biological monitoring programs (and extant data associated with them) to identify and stimulate research and development on improving the quality and cost-effectiveness of monitoring programs." CEQ and GIWG are considering both sets of recommendations in developing future plans aimed at making government resource information more useful.

The GIWG has focused on development of a Perspective Paper on International Environmental Issues as a primary goal for 1985. Substantial work, done during 1984 by GIWG member agencies on various international environmental issue papers, reaffirmed the need for such a Perspective Paper to provide consistency of philosophy and approach for issue papers. Forming and articulating a perspective that fairly represents a consensus of existing viewpoints is an arduous and time-consuming task; however, substantial progress has been made.

Additionally, during 1985 the GIWG will continue to respond to current international environmental concerns and requests of international organizations, such as overseeing the development of the U.S. response to the United Nations Economic Commission for Europe (ECE) request for a "National Review of Environmental Policies and Strategies."

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Chapter 12

The National Environmental Policy Act

On January 1, 1970, President Nixon signed into law the National Environmental Policy Act (NEPA).[1] The statute ushered in what has been called the "environmental decade." Indeed, the vast majority of modern federal environmental protection legislation was enacted between January 1, 1970 and December 11, 1980, when the "superfund" law was signed by President Carter.

NEPA articulated for the first time both a comprehensive federal environmental policy and a method by which government proposals could be weighed and evaluated in the light of environmental needs and goals. NEPA declares that:

> ". . . it is the continuing policy of the Federal Government, in cooperation with state and local governments, and other concerned public and private organizations, to use all practicable means and measures, including financial and technical assistance, in a manner calculated to foster and promote the general welfare, to create and maintain conditions under which man and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Americans."[2]

The National Environmental Policy Act and the Council on Environmental Quality

Besides articulating goals and policies for the nation, NEPA established the Council on Environmental Quality in the Executive Office of the President and directed it to assume responsibility for advising, coordinating, and monitoring agency implementation of this new law. In Section 102(2)(C), NEPA instructed all federal agencies to prepare a "detailed statement" regarding each proposal "for legislation and other major federal actions significantly affecting the quality of the human environment," including a description of the environmental impact of the proposed action; any adverse environmental effects that cannot be avoided should the proposal be implemented; alternatives to the proposed action; the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity; and any irreversible and irretrievable commitments of resources that would be involved in the proposed action should it be implemented.[3] This requirement has evolved into the environmental impact assessment process.

Since its establishment in 1970, the Council on Environmental Quality (CEQ) has actively monitored federal agency implementation of the environmental impact assessment process. In 1970, CEQ issued interim guidelines[4] for the preparation of environmental statements; these were made final in 1971[5] and amended in 1973.[6] In 1978, CEQ was authorized by Executive Order[7] to issue regulations to implement the procedural provisions of NEPA that would be

binding on all federal agencies. CEQ was ordered to write the regulations in a way which would make the environmental assessment process "more useful to decision makers and the public; and to reduce paperwork, and the accumulation of extraneous background data, in order to emphasize the need to focus on real environmental issues and alternatives."[8]

CEQ implements its oversight of the environmental assessment process in a number of ways: routinely reviewing the agencies' implementation and interpretation of the CEQ NEPA regulations; answering questions from government agencies and the private sector about the regulation's applicability to a specific situation; arriving at a policy interpretation of a regulatory question; and analyzing the effectiveness and impact of the regulations to determine whether there is a need for amendment. In addition, CEQ reviews each individual agency's NEPA procedures for consistency with the CEQ regulations[9] and resolves disputes as to which agency is the "lead agency" for preparation of environmental impact statements.[10] The CEQ regulations also establish procedures for referring to the CEQ interagency disagreements concerning proposed major federal actions that might cause unsatisfactory environmental effects.[11]

CEQ NEPA Regulations: Activities in 1984

During 1984, the Council approved revisions to agency NEPA procedures for the Department of the Interior, the General Services Administration, the National Park Service, the Food and Drug Administration, and the National Oceanic and Atmospheric Administration. CEQ also published three appendices to the NEPA regulations, which contain information regarding (1) agency NEPA contacts; (2) agencies with jurisdiction by law or special expertise on environmental quality issues; and (3) agency offices for receiving and commenting on other agencies' environmental documents.[12]

CEQ did not amend its NEPA regulations during 1984 but did continue to focus attention on the "worst case analysis" requirement found in the regulation dealing with "Incomplete or unavailable information," which is found at 40 CFR 1502.22 (1984). That regulation requires the preparation of a worst case analysis when an agency prepares an environmental impact statement and when information relevant to significant adverse impacts that is essential or important to a decision is missing and the costs of obtaining it are exorbitant or the information cannot be obtained. The questions of precisely when such an analysis is required, what it must contain, how the "worst case" is identified, and related issues have been the focus of an increasing amount of attention since the *Sierra Club v. Sigler*[13] decision in 1983. At the end of the year, CEQ published an Advance Notice of Proposed Rulemaking,[14] which solicited written responses to the following questions:

1. Under what circumstances and to what extent must a federal agency engage in forecasting or speculation when confronted with scientific uncertainty or gaps in information concerning the environmental effects of a proposed action?
2. How can an analysis be structured to present reasonable forecasting in the face of scientific uncertainty or information gaps about the effects of a proposed action to provide more useful and understandable information for decision-makers and other interested parties?

3. Does the type of analysis called for in 40 CFR 1502.22 require federal agencies to go beyond the "rule of reason," as traditionally expressed in judicial decisions interpreting NEPA?
4. Should a threshold standard be established, which would trigger the preparation of the type of analysis identified in response to question one, such as a threshold of severe consequences, a threshold of probability, or a threshold of scientific credibility?
5. Is the term "worst case" appropriate for this type of analysis? If so, how should it be defined? If not, what is the most appropriate term for this type of analysis, and how should it be defined?

NEPA and the Courts: 1984 Litigation

United States Supreme Court

During the 1983–1984 term, the Supreme Court did not hear any cases involving a cause of action under NEPA. The U.S. Government presented a petition for a *writ of certiorari* in the case of *Clark v. Southern Oregon Citizens Against Toxic Sprays, Inc.*,[15] decided last year by the Ninth Circuit, involving the worst case analysis issue. However, that petition was denied by the Supreme Court.

United States Courts of Appeals (Selected Decisions)

Save Our Ecosystems v. Clark and *Merrell v. Block*, 747 F.2d 1240 (9th Cir. 1984). In these consolidated cases, the Ninth Circuit ruled on the adequacy of a worst case analysis prepared by the Bureau of Land Management (BLM) in connection with proposed herbicide spraying of public lands, and also addressed the issue of agencies' research responsibilities under NEPA.

The worst case analysis prepared by the BLM set out "no observed effect" dosage levels for each of the herbicides proposed for use and calculated the highest dosages of the herbicides that might be received by persons applying the herbicides and by persons who lived near or used the affected areas. The analysis compared maximum exposure levels to the observed "no effects levels" for toxic impacts other than cancer and genetic effects and concluded that the proposed use of the herbicides would entail no human health hazards. BLM found that current literature did not indicate that potential chronic genetic effects would occur as a result of "worst case" dosages, nor was there reliable evidence showing that the herbicides caused cancer. Therefore, the agency argued, they could not make meaningful projections regarding carcinogenicity and mutagenicity.

The Ninth Circuit upheld the lower court's ruling that BLM's worst case analysis was inadequate because it did not assume that the herbicides had carcinogenic and mutagenic effects. Because of some degree of uncertainty in the scientific community, the agency was obligated to discuss the most pessimistic effects of the proposed use of the herbicides.

The Ninth Circuit also found that agencies may not rely on EPA's registration process for herbicides under the Federal Insecticide, Fungicide, and Rodenticide

Act (FIFRA) to fulfill their NEPA responsibilities and that they may be required to do independent research on the health effects of an herbicide.

Village of False Pass v. Clark, 733 F.2d 605 (9th Cir. 1984). In this decision, the court held that the Department of the Interior's failure to include a worst case analysis of a very large (100,000 barrel) oil spill in its environmental impact statement (EIS) did not violate NEPA. The Village challenged the Department of the Interior's sale of oil and gas leases (Lease Sale 70) in the St. George Basin, located off the west coast of Alaska in the Bering Sea. They claimed that the Secretary's decisions were based on inadequate information and that his decision violated NEPA because it failed to include a worst case analysis of major oil spills and the impact of the lease sale on the resources of the St. George basin, which include gray and right whales.[16] The district court had concluded that NEPA did not require a worst case analysis of the effects of a major oil spill at the lease sale stage.[17] The court reasoned that oil spills could occur only in stages subsequent to the lease sale, such as the development or production stages. Additional environmental information about the impact would be available in these later stages and should be considered at that time.[18]

On appeal, the court first resolved which of the two CEQ standards for requiring a worst case analysis should now apply; that is,

> "(b) If (1) the information relevant to adverse impacts is essential to a reasoned choice among alternatives and is not known and the overall costs of obtaining it are exorbitant or (2) the information relevant to adverse impacts is important to the decision and the means to obtain it are not known (e.g., the means for obtaining it are beyond the state of the art) . . . "[19]

Concluding that the "important to the decision" test applied, the court explained that the parties agreed that if this test did not justify a worst case analysis, neither would the "essential to a reasoned choice" test.[20] The appellate court then examined the plaintiff's two main NEPA arguments. First, they contended that the Outer Continental Shelf Land Act (OCSLA) provisions for suspension and the cancellation of a lease required a high probability of harm to the environment and therefore would not apply to a worst case situation. This, the plaintiffs claimed, increased the importance of conducting a worst case analysis at the lease sale stage.[21] Second, they claimed that a worst case analysis in the later stages was unlikely because OCSLA only requires an EIS for one development and production plan in the entire lease sale.[22]

The Court of Appeals rejected both of these arguments. The court stated that OCSLA requirements are not exclusive and that the Secretary of the Interior has complete discretion to modify or cancel a lease under NEPA. The court held that here the Secretary did not abuse that discretion in determining that information regarding a 100,000 barrel oil spill was not important at the lease sale stage.[23] Dismissing the plaintiff's second argument, the court explained that OCSLA sets a minimum standard that does not limit the applicability of NEPA to approval of any other plans.[24]

In a dissenting opinion, one judge found that once the expenditures for leases and the decision to proceed are made, a momentum for development is created that is hard to reverse.[25] Hence, he would have required the preparation of a worst case analysis at the lease sale stage.

Duekmejian v. N.R.C., 751 F.2d 1287 (D.C. Cir. 1984). In this lawsuit, petitioners, who lived and worked in the vicinity of the Diablo Canyon Nuclear Power Plant, intervened in the NRC's proceedings for granting licenses for low power and full power operations of the plant. The NRC had prepared an EIS for the plant in 1973 and supplemented it in 1976. Neither the EIS nor the supplement made any significant analyses of a "core melt" (Class Nine) accident. The consequences of such an accident are catastrophic and their probability extremely low; therefore, the NRC maintained a policy of not requiring a detailed discussion of these accidents in its EISs.

Two events led the NRC to reverse its policy. The first was the findings of a 1978 Risk Assessment Group that it was unable to determine the absolute probability of these accidents; the second was the Three-Mile Island accident. The NRC published a Statement of Interim Policy in 1980 directing that future EISs include discussions of impacts attributable to sequences that could result in the release of radiation and/or radioactive materials, including core melts. This policy was to apply retroactively to a final EIS only where "special circumstances" exist.[26]

Petitioners contended that the NRC violated its duty to supplement a final EIS by allowing the Statement of Interim Policy to apply retroactively only where special circumstances exist. In addition, they argued that the policy was invalid because a worst case analysis was not prepared.[27] Finally, they contended that if the court found that the NRC could deny the policy's retroactive effect, then the presence of the Hosgri fault within three miles of the Diablo Canyon site constitutes the special circumstances that allow the policy to apply retroactively.

The Court of Appeals rejected the petitioners' arguments, finding that agencies are not obligated to discuss in detail in EISs or supplemental EISs events whose probabilities are inconsequentially small. The Interim Policy was a discretionary policy choice and the NRC was free to deny its retroactive effect.[29] The court did *not* speak to the issue of whether a worst case analysis is required in this case because the CEQ regulations, including requirements for a worst case analysis, did not apply to the EISs at issue in this case.[30] The final EIS for Diablo Canyon and the supplemental EIS were filed in 1973 and 1976 respectively. The CEQ regulations became effective on July 30, 1979 and state, "These regulations do not apply to an environmental impact statement or supplement if the draft statement was filed before the effective date of the regulations."[31]

Finally, the court found that the NRC determined that the chance that an earthquake could trigger a nuclear accident is extremely small. Because the court finds that both the probability and the magnitude of a nuclear accident are to be considered in determining if special circumstances exist, the court held that the risk presented here was not the type of situation that constitutes the exceptions envisioned by the Statement of Interim Policy.[32]

Wisconsin v. Weinberger, 745 F.2d 412 (7th Cir. 1984). In this case, the U.S. Court of Appeals for the Seventh Circuit addressed the often asked question of when an agency is required to prepare a supplemental EIS, and also ruled on the issue of when to grant an injunction in a NEPA case. In this instance, plaintiffs sought to require the Department of the Navy to prepare a supplemental EIS in connection with Project ELF, an extremely low frequency submarine communications system. Plaintiffs contended that the original EIS should be supplemented because of new information regarding the biological

effects of extremely low frequency electromagnetic radiation. The District Court agreed and enjoined the Navy from proceeding until a supplemental EIS was prepared.[33] Reversing the order, the Court of Appeals unanimously agreed that the lower court erred in granting an injunction, but split on the issue of the need for a supplemental EIS.

With regard to the issue of whether a supplemental EIS was required, both the majority and the dissent started with the CEQ regulations that require an agency to supplement an EIS if (1) the agency makes substantial changes in the proposed action that are relevant to environmental concerns; or (2) there are significant new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts.[34] The majority found the need to formulate an additional standard that would give the term "significant" more precise meaning in the context of determining whether a supplemental EIS is required. The court stated its belief that:

> "[An] important difference between an agency's decision whether to file an initial EIS and its decision whether to supplement an EIS is that the decision to supplement is made in light of an already existing, in-depth review of the likely environmental consequences of the proposed action. . . . The issue is whether the subsequent information raises new concerns of sufficient gravity such that another, formal in-depth look at the environmental consequences of the proposed action is necessary. The supplementation process is extensive and an agency's determination as to when one is or is not needed is entitled to some deference. We hold, therefore, that an agency cannot have acted arbitrarily or capriciously in deciding not to file a SEIS unless the new information provides a *seriously* different picture of the environmental landscape such that another hard look is necessary."[35]

In examining the new information related to this ELF proposal, the majority concluded that it did not rise to the level of the standard articulated in the court's holding.[36]

The dissent agreed with the majority that the new scientific information alone, in the absence of other factors, was not so significant as to require a supplemental EIS. Citing the 1980 decision of the Ninth Circuit Court of Appeals in *Warm Springs Dam Task Force v. Gribble*,[37] the dissent stressed that the duty to monitor new and relevant information after preparation of an EIS exists even if the new information does not raise the level of "significance" that triggers the requirement to prepare a supplement EIS.[38] Because the District Court found that the Department of the Navy had violated that duty, the dissent on the Court of Appeals would have found that preparation of a formal supplemental EIS was an appropriate remedy.

Both the majority and dissent agreed that the lower court had erred in not balancing the equities prior to issuance of an injunction halting the Navy's work on Project ELF until completion of an supplemental EIS. The District Court had concluded that no balancing analysis was appropriate in a NEPA case because permitting an agency to proceed with an action prior to compliance with NEPA would moot NEPA's predecisional thrust. The Court of Appeals disagreed, finding nothing in NEPA to restrict a court's traditional equitable jurisdiction. Thus, the court concluded that "the District Court abused its discretion by failing to consider the degree to which the NEPA interests would, in

fact, be served by an injunction, the efficacy of other forms of relief, and the harm to national defense interests that would result."[39]

National Wildlife Federation v. Marsh, 721 F.2d 767 (11th Cir. 1983). In this case, the U.S. Court of Appeals for the Eleventh Circuit reversed the District Court and ruled that a supplemental EIS was required to evaluate a proposed mitigation plan for construction of Lake Alma, a man-made lake in Georgia. The project, which had been the subject of previous litigation and a referral to CEQ, required a permit from the Corps of Engineers under Section 404 of the Federal Water Pollution Control Act, as amended by the Clean Water Act.[40] The Corps of Engineers decided to issue the Section 404 permit, but only on condition that a mitigation plan, issued by the Fish and Wildlife Service, was implemented. The mitigation plan had not been analyzed in any previous EIS for the Lake Alma project, although it had been the subject of a study that was ordered by the Corps of Engineers and prepared by the Georgia Department of Natural Resources.

Plaintiffs argued that adoption of the mitigation plan was a significant change in the proposed action that required preparation of a supplemental EIS. Defendants maintained that no supplemental EIS was required because "no substantial *adverse* effect to the environment would result" from implementation of the mitigation plan.[41]

The Court of Appeals, relying on *EDF v. Marsh's* holding that changes in a project that are beneficial to the environment or are intended to mitigate environmental impacts require a supplemental EIS if those changes are significant, found that the mitigation plan proposed in connection with the construction of Lake Alma "involves a number of proposed project changes that are likely to have a significant, though beneficial, impact on the environment in and around the proposed lake."[42] Thus, the court concluded, preparation of a supplemental EIS was required.

Forelaws on Board v. Johnson, 743 F.2d 677 (9th Cir. 1984). An alleged conflict between NEPA and the Pacific Northwest Electric Power Planning and Conservation Act was at issue in this case. The Act requires that the Bonneville Power Administration (BPA) establish a new system of long-term contracts governing the delivery of power to its customers and encourage its customers to conserve energy and take measures to protect the Pacific Northwest's environment. Plaintiffs contended that the BPA violated NEPA when they failed to prepare an EIS before they offered the contracts.[43]

The BPA first argued that even though these 145 contracts of 20-year duration did constitute a major federal action, the contracts themselves did not significantly affect the human environment. The court dismissed this argument, however, finding that the contracts would have significant effects on regional energy plans and conservation, as well as fish and wildlife.[44] The BPA's principal argument was that the time limitations of the Act for contract offer and acceptance made it impossible for them to prepare an EIS. The Act gave the BPA nine months upon its effective date to offer the contracts. The customer then had to accept the contract within one year. The BPA also attempted to bring itself within the doctrine established by the U.S. Supreme Court in *Flint Ridge Development Co. v. Scenic Rivers Association of Oklahoma*, in which a 30-day requirement of the Interstate Land Sales Act and NEPA created an irreconcilable and fundamental conflict.[45] The BPA argued that they too only

had 30 days to prepare an EIS in light of time spent in negotiations with customers, holding public meetings, and issuing draft prototype contracts.[46]

The court, in rejecting BPA's claim, stated that there is nothing in the legislative history of the Act to indicate that Congress intended to exempt BPA's activities under the Act from NEPA. Further, BPA's argument that they only had 30 days to prepare an EIS was based on their own schedule and not a schedule required by the Act. BPA could have performed an EIS and still have met the statutory deadline. Given the legislative history and the "lack of any mandated deadlines remotely similar to the 30 days of *Flint Ridge* and the broad construction we are compelled to give NEPA,"[47] the court concluded that there was no irreconcilable conflict between NEPA and the Act and that the BPA's failure to prepare an EIS for the contract offers constituted a violation of NEPA.[48]

Glass Packaging Institute v. Regan, 737 F.2d 1083 (D.C. Cir. 1984). This case focused on the issue of whether potential criminal activity should be considered in NEPA documents. Plaintiffs, a trade association of glass bottle manufacturers, challenged the adequacy of the Bureau of Alcohol, Tobacco and Firearms' (BATF) environmental assessment prepared regarding the use of the plastic bottles, which concluded with a Finding of No Significant Impact. The environmental assessment did not discuss the possibility of criminal tampering with the plastic bottles. Plaintiffs alleged that BATF should analyze the possibilities that a "deranged criminal could inject poisons through the plastic walls" of the bottles.[49]

The U.S. Court of Appeals for the District of Columbia Circuit rejected the argument that the possible reasonably forseeability of the criminal acts of third parties triggered a duty to consider the alleged environmental effect. Specifically, the court declined to find that the susceptibility of plastic bottles to tampering is an environmental effect, cognizable under NEPA. Instead, the court expressed serious "doubt whether Congress fashioned NEPA as an administrative incarnation of the policeman's squad car, roving the streets in search of sporadic criminal activity which may occasionally occur in the aftermath of an agency action. . . ."[50] The court felt that plaintiff's interpretation of the "environment" stretched far beyond either Congress' or the Supreme Court's interpretation of "environment."[51]

United States District Courts (Selected Decisions)

National Wildlife Federation v. U.S. Forest Service, 592 F.Supp. 93 (D. Or. 1984), *Amended* (D. Or. Aug. 6, 1984). The worst case analysis continued to be the subject of litigation in district courts during 1984. For example, in this case, plaintiffs successfully challenged a Forest Service Seven Year Action Plan for the Mapleton District of the Siuslaw National Forest. The Plan contained the location and lengths of proposed roads and the approximate volume of timber to be removed during each year's timber sale. The Mapleton District is particularly susceptible to soil erosion and has the highest concentration of landslides in the Siuslaw National Forest. To protect particularly vulnerable areas from soil erosion, and concomitant damage to soil, water, and fishery resources, the Forest Service proposed to designate such areas as "vegetative leave areas" in which timber would not be harvested.

The U.S. District Court for the District of Oregon determined that the Seven Year Action Plan was a proposal for a major federal action that significantly affects the human environment and hence requires preparation of an EIS. The Forest Service had maintained that annual environmental assessments for each timber sale in the Seven Year Action Plan, along with a Timber Resource Plan programmatic EIS covering the entire Siuslaw National Forest, would adequately cover the site-specific impacts. The District Court found two flaws with this scheme: (1) there was no consideration of the cumulative impacts of all of the timber sales in the Mapleton District, and (2) there was no worst case analysis examining the effectiveness of leave areas in preventing landslides. The court stated that "Landslides damage fish habitats, but it is uncertain whether leave areas used by the Forest Service will effectively prevent landslides. Without accurate evidence of the effectiveness of leave areas as mitigation techniques, the Forest Service must prepare a worst case analysis."[52]

Foundation on Economic Trends v. Heckler, 587 F.Supp. 753 (D. D.C. 1984). The first judicial decision applying NEPA to the release of recombinant DNA organisms into the environment was issued in 1984 in this case. The lawsuit concerned the decision of the Director of the National Institutes of Health (NIH), aided by an advisory committee called the Recombinant DNA Advisory Committee (RAC), to permit scientists from the University of California at Berkeley to conduct an experiment involving the application of genetically altered bacteria onto a row of potatoes in northern California. The goal of the experiment was to increase the ability of the plants to resist frost damage. Neither an environmental assessment nor an EIS was prepared by NIH prior to approval of the proposed experiment. Plaintiffs argued that NIH was obligated to prepare both a programmatic EIS addressing the alteration of the NIH Guidelines for Research Involving Recombinant DNA Molecules and, at minimum, an environmental assessment for NIH's authorization of the University of California experiment.

NIH had prepared an EIS for the original set of guidelines issued in 1976. The guidelines established standards that research scientists must follow in their handling of recombinant material if they are to receive NIH funding. At that time, the guidelines explicitly prohibited the deliberate release of recombinant DNA into the environment, and the EIS did not discuss the environmental effects of such action. In 1978, the guidelines were revised. Among the changes was a revision that granted the Director of the NIH the authority to grant exceptions to the prohibitions contained in the original 1976 guidelines, including the prohibition against deliberate release experiments. Although the revision to the guidelines was accompanied by environmental assessments, they did not assess the environmental impacts of such experiments. Instead, the Director stated that he would determine the necessity for an environmental assessment or an EIS on a case-by-case basis. No NEPA document was prepared prior to authorization of the University of California experiment.

The court, characterizing the guidelines as a "comprehensive Federal program which purports to directly govern all NIH-related research involving the deliberate release of recombinant material into the environment," determined that the changes made to the guidelines in 1978 were a major federal action, and that there was substantial likelihood that both direct and cumulative potential impacts would warrant preparation of a programmatic EIS.[53] Further, the

court found that the lack of an environmental assessment prior to approval of the University of California experiment indicated that NIH had failed to take the "hard look," required by NEPA, at the environmental impacts of such experiments.[54] The court was not sympathetic to defendants' claim of laches, nor did the court believe that the "functional equivalent doctrine" used by the Environmental Protection Agency could be applied to NIH. The court did agree that NEPA responsibilities would not apply to NIH reviews of proposed experiments from private corporations on a voluntary basis, without any legal control or authority or federal funding involved. The court granted plaintiffs' motions for preliminary injunction, insofar as they related to preparation of a programmatic EIS for the modified guidelines and the University of California experiment, and denied the preliminary injunction in relationship to the private experiment.

Trends in NEPA Litigation

During 1983, 146 NEPA cases were filed in federal court — a slight drop from the 157 cases filed in 1982. Twenty-one of the 146 lawsuits resulted in injunctions.

The Department of the Interior was sued 36 times, comprising 25 percent of the total number of cases. Other agencies sued a significant number of times included the Department of Transportation (24 lawsuits or 16 percent of the total) and the Department of the Army (14 lawsuits or 9 percent of the total). The most frequently sued independent agencies were the Federal Energy Regulatory Commission and the Nuclear Regulatory Commission, each named as defendants in five lawsuits filed during 1983. The number of NEPA lawsuits for all agencies in the federal government is presented in Table 12–1.

Individuals or citizen groups brought the most NEPA lawsuits during 1983, with a total of 57 complaints filed, (31 percent of the total number). Environmental groups were next in frequency as plaintiffs, filing 55 lawsuits. Business groups and state governments each brought 17 lawsuits, as did directly affected property owners and residents. Local governments filed 13 lawsuits; Indian tribes filed five lawsuits, and legal foundations were plaintiffs in two NEPA cases. Table 12–2 lists the types of plaintiffs with their respective totals.

During 1983, the most frequent allegation in NEPA lawsuits was that an agency failed to prepare an environmental impact statement in a situation in which one was required. Sixty-three lawsuits were based on that complaint, which, except for last year, has traditionally been the most frequently litigated NEPA issue. The complaint that an agency's environmental impact statement was inadequate was at issue in 58 lawsuits. Fourteen lawsuits involved an allegation that an environmental assessment was inadequate, and 25 cases were filed for various miscellaneous allegations. Table 12–3 summarizes the types of complaints in 1983 NEPA lawsuits.

The Environmental Protection Agency reported a total of 577 EISs filed during 1984. Table A–69 at the end of the report shows the number of EISs filed by each agency.

Table 12-1. Agencies Reporting NEPA Cases Filed, 1983

	Number of Cases	Number of Cases Resulting in Injunctions
Department of the Interior	36	4
Department of Transportation	24	1
Department of Agriculture	18	3
Department of the Army	14	2
Department of Commerce	8	2
Department of Housing & Urban Development	8	2
Environmental Protection Agency	7	2
Department of Justice	6	3
Federal Energy Regulatory Commission	5	0
Nuclear Regulatory Commission	5	0
Department of the Navy	4	1
Department of the Treasury	3	0
Interstate Commerce Commission	3	0
Department of the Air Force	1	0
Department of Energy	1	0
Federal Communications Commission	1	0
Department of Health & Human Services	1	1
National Aeronautics & Space Administration	1	0
	146	21

Table 12-2. Plaintiffs in NEPA Cases, 1983

Type of Plaintiffs	Number
Individuals or Citizen Groups	57
Environmental Groups	55
State Governments	17
Business Groups	17
Directly Affected Property Owners & Residents	17
Local Governments	13
Indian Tribes	5
Legal Foundations	2
	183

Table 12-3. Types of Complaints

No EIS when one should have been prepared	63
Inadequate Environmental Impact Statement	58
Inadequate Environmental Assessment	14
Other	25

Special Report: Agency Referrals to CEQ

The Referral Process

The CEQ referral process permits federal agencies to bring to CEQ interagency disagreements concerning proposed major federal actions that might cause unsatisfactory environmental effects. Under Part 1504 of the CEQ NEPA regulations,[55] any federal department or agency may refer a proposed major federal action to CEQ no later than 25 days after the final EIS has been made available to the Environmental Protection Agency, commenting agencies, and the public. Under Section 309 of the Clean Air Act,[56] the Administrator of the Environmental Protection Agency has broader authority to refer to CEQ any proposed legislation, action, or regulation that he deems unsatisfactory from the standpoint of public health or welfare or environmental quality. The referral letter must be signed by the head of the referring agency. In the case of an agency within a department, this means the head of the department.

A federal agency that is referring a proposal to CEQ must notify the lead agency of its intentions at the earliest possible time. If the issues have not been resolved between the agencies after publication of the final EIS, and an agency wishes to refer the proposal to CEQ, the referring agency must send a letter and statement to CEQ and the lead agency and request that no action be taken to implement the proposal until CEQ acts upon the referral. The statement accompanying the referral letter must: (1) identify the material facts in the controversy; (2) identify environmental policies or requirements that would be violated by the proposal; (3) present the reasons why the referring agency believes the proposal is environmentally unsatisfactory; (4) contain a finding that the issue raised is of national importance; (5) review the steps taken by the referring agency to resolve the matter with the lead agency prior to referral; and (6) offer the referring agency's recommendations in regard to the proposed action.

The lead agency for the proposal then has 25 days to respond to the referring agency's letter and statement. Interested parties, both in and outside of government, may deliver written views in support of the referral to CEQ no later than the referral is transmitted to CEQ; parties wishing to submit written comments in support of the lead agency's position may deliver them to CEQ no later than the lead agency's response.

After the response to the referral has been received, CEQ may take one of seven actions:

"(1) Conclude that the process of referral and response has successfully resolved the problem.

"(2) Initiate discussions with the agencies with the objective of mediation with referring and lead agencies.

"(3) Hold public meetings or hearings to obtain additional views and information.

"(4) Determine that the issue is not one of national importance and request the referring and lead agencies to pursue their decision process.

"(5) Determine that the issue should be further negotiated by the referring and lead agencies and is not appropriate for Council consideration until one or more heads of agencies report to the Council that the agencies' disagreements are irreconcilable.

"(6) Publish its findings and recommendations (including where appropriate a finding that the submitted evidence does not support the position of an agency).

"(7) When appropriate, submit the referral and the response together with the Council's recommendation to the President for action."[57]

History of Referrals

CEQ Guidelines first provided for referrals from the Environmental Protection Agency in 1973. The guidelines did not have specific criteria for a referral to the Council; rather, they simply stated that:

> "In all cases where EPA determines that proposed agency action is environmentally unsatisfactory, or where EPA determines that an environmental statement is so inadequate that such a determination cannot be made, EPA shall publish its determination and notify the Council as soon as practicable."[58]

It became clear that there was a need for further guidance on implementing the relevant statutes. Thus, on August 11, 1977, the Council issued an "Interim Guidance to Federal Agencies on Referrals to the Council on Proposed Federal Actions Found to be Environmentally Unsatisfactory."[59] The Interim Guidance was superseded by the current CEQ regulations.

The current CEQ regulations codify the criterion of "national importance" as a prerequisite to acceptance of a referral. The purpose of the national importance provision in the NEPA regulations reflects CEQ's concern.

> ". . . The referral process be limited to truly important matters—matters of national importance—that might properly engage the attention of the President's Executive Office or even the President. We did not believe that the fact that an environmental impact statement had been prepared made a project or policy one of national importance. Nor would the fact of an interagency controversy, standing alone, make something of national importance. Our goal was to focus attention on a very small but very important subset of controversial federal proposals. We were trying to ensure that the process would not be open to all controversial proposals for which environmental impact statements had been prepared, because we did not want to burden ourselves, our colleagues in the EOP, or the President with proposals that were not of national importance."[60]

There have been 22 referrals to CEQ since 1974, as listed in Table 12–4. When CEQ takes a referral, it most frequently engages in discussion with the involved agencies and other interested parties, with the objective of mediation and publication of CEQ's findings and recommendations. In the course of several referrals, interagency agreements to proceed with the project in a manner that incorporated features to significantly moderate adverse environmental impacts have been reached. In some cases, proposals have been withdrawn after the referral process has been concluded. In a few instances, CEQ has determined that the issue raised in the referral was not one of national importance and requested the referring and lead agencies to pursue their decision process.

During 1982 and 1983, there were no active referrals.[61] During 1984, however, CEQ received two referrals. The first, referred to CEQ by the Advisory Council on Historic Preservation, concerned the proposed Presidential Parkway in Atlanta, Georgia. The Federal Highway Administration was the lead agency for the project and had responsibility for approving or disapproving the State of Georgia's application for federal aid under the federal-aid urban system.

CEQ's initial examination of the referral focused on the question of whether the referral raised an issue of "national importance." Each Council Member visited the site of the proposed 2.4 mile parkway and met individually with interested parties in the public and private sector. CEQ also held a public meeting to discuss the referral and published a *Federal Register* notice asking for written comments from the public on the issue of national importance.[62] Based on this record, the Council determined that the referral did not raise an issue of national importance and requested the lead and referring agencies to resume their normal decision process.[63]

On December 28, 1984, the Department of the Interior referred to CEQ the Department of the Army, Corps of Engineers' proposed Tennessee-Tombigbee Waterway Wildlife Mitigation Feasibility Study for areas of Alabama and Mississippi. The two basic issues raised in the referral were (1) in-kind replacement of bottomland hardwood areas; and (2) the use of land on other projects for mitigating habitat losses on the Tennessee-Tombigbee. The results of that referral will be discussed in the 1985 Environmental Quality Report.

During the latter half of 1984, there was increased interest in the referral process on the part of federal agencies and members of the public. At the same time, the Council realized that little work had been done to collect information about past referrals or to analyze the effectiveness of the referral process. Thus, CEQ, in cooperation with the Department of the Interior and the Environmental Protection Agency, compiled summaries of each of the referrals, including information about the basis for the referral, the actions taken during the referral process, and the results of the referral. These summaries are reprinted as an Appendix to this chapter.

Additionally, in cooperation with the Environmental Protection Agency and the Environmental Law Institute, CEQ plans to publish an expanded study of the referral process, to analyze the impact of the referral process on the proposals that are the subject of the referrals. The study should assist CEQ in evaluating and improving the process, as well as provide information to persons interested in current and future referrals.

Table 12-4. Referrals of Interagency Disagreements to CEQ

Project	Lead Agency	Referring Agency	Date of Referral
1. Shearon Harris Nuclear Power Plants Units 1–4, Wake & Chatham Counties, North Carolina	AEC	EPA	1/10/74
2. Phosphate Leasing on Osceola National Forest, North Central Florida	BLM	EPA	12/31/74
3. Oil & Gas Lease Sale No. 39, Northern Gulf of Alaska, Outer Continental Shelf	BLM	EPA	12/18/75
4. Permit Application by Deltona Corporation, Marco Island, Collier County, Florida	COE	EPA	3/15/76
5. Kaiparowits Power Plant, Kaiparowits, Plateau, Utah	BLM	EPA	6/4/76
6. Westside Highway Project, New York City, New York	FHW	EPA	2/14/77
7. Lake Alma Project, construction of water reservoir, Alma, Bacon County, Georgia	HUD	EPA	3/24/77
8. Wando & Cooper Rivers, Permit, Dredge, Fill, Construction—Marine Terminal, Charleston County, South Carolina	COE	EPA	4/20/77
9. County Trunk Highway "Q," Kenosha County, Wisconsin	FHW	EPA	12/9/77
10. Barge Terminal Expansion, Packer River Terminal, Dakota County, Minnesota	COE	EPA	1/11/78
11. Proposed Foothills Project, Colorado	BLM	EPA	1/17/78
12. Fire Island to Montauk Point, beach erosion control & hurricane protection project, New York	COE	DOI	3/7/78
13. Central and Southern Florida Flood Control Project, Hendry County, Florida	COE	DOI	3/9/79
14. I-84 & I-86, East Hartford-Manchester, Hartford County, Connecticut & Rhode Island	FHW	EPA	12/13/79
15. I-476, Mid-County Expressway, Delaware & Montgomery Counties, Pennsylvania	DOT	DOI	11/10/80

Table 12-4 Referrals of Interagency Disagreements to CEQ—Continued

Project	Lead Agency	Referring Agency	Date of Referral
16. Jackson Hole Airport, airport dispute, aviation noise, Jackson Hole, Wyoming	DOT	DOI & EPA	1/9/81
17. Elk Creek Dam, resulting in the prolonged period of increased turbidity in the Rogue River, Elk Creek Lake, Oregon	COE	DOI	1/19/81
18. Dickey-Lincoln Schools Lake Project, proposed dam of St. John River, Maine	COE	DOI	9/28/81
19. Palmdale International Airport, Los Angeles County, Palmdale, California	FAA	DOD	8/31/82
20. Presidential Parkway, Fulton & DeKalb Counties, Atlanta, Georgia	FHWA	ACHP	6/25/84
21. Tennessee-Tombigbee Wildlife Mitigation Plan, Alabama and Mississippi	COE	DOI	12/28/84
22. Corps of Engineers NEPA Procedures	COE	EPA	2/15/85

APPENDIX: SUMMARIES OF REFERRALS TO CEQ
(In Chronological Order)

Phosphate Leasing in the Osceola National Forest North Central Florida

proposal: Permittees applied for preference right leases to mine in the Osceola National Forest (Florida) for phosphate.

lead agency: Bureau of Land Management, Department of the Interior.

referred by: Environmental Protection Agency.

referral date: December 31, 1974.

referral basis: The Environmental Protection Agency determined that the Department of the Interior (Bureau of Land Management) proposal, based on its magnitude and irreversible impact, would be unsatisfactory from the standpoint of environmental quality and public welfare and referred the proposal to the Council in

accordance with Section 309 of the Clean Air Act (42 U.S.C. 7609). In EPA's opinion it would have been "impossible satisfactorily to mitigate the desctruction of 28,000+ acres of the Osceola ecosystem. . . ." *Referral Letter from Deputy Administrator, EPA, to Chairman, CEQ*, December 31, 1974.

national importance: *NOTE:* When this proposal was initially referred to the Council, the August 11, 1977 CEQ Interim Guidance had not been issued and the CEQ Regulations had not been promulgated. Section 309 of the Clean Air Act (42 U.S.C. 7509 [1970]) and Section 1500.9(b) of the CEQ Guidelines (38 *Fed. Reg.* 20555 [1973]) called for referral to CEQ, by EPA, certain matters determined to be unsatisfactory from the standpoint of public health or welfare or environmental quality. The Interim Guidance, which was superceded by Part 1504 of the CEQ Regulations, set procedure and established criteria (including national importance) for referring a proposal.

Although discussion of "national importance" was not required when the proposal was referred, there was some discussion of the federal interest involved:

"Since, in our opinion, it will be impossible satisfactorily to mitigate the destruction of 28,000+ acres of the Osceola ecosystem, and in view of upcoming related proposals for other Federal lands, we strongly recommend that no leases for phosphate mining in the Osceola National Forest should be issued at this time."

"No additional phosphate leases should be issued for Federal lands pending the issuance of the EIS and subsequent findings." *Referral Letter from Deputy Administrator, EPA, to Chairman, CEQ*, Dec. 31, 1974.

"The BLM's EIS and the EPA's subsequent analysis present ample evidence that mining phosphates in the Osceola National Forest would cause widespread ecological destruction and would pose serious threats to the human environment. We believe that such a proposal dramatically conflicts with the purposes of NEPA and with the purpose for which the National Forest was acquired." *Letter from Chairman, CEQ, to Secretary of the Interior*, Mar. 18, 1975.

"As you know, the President wishes to have a status report from the Council on Environmental Quality on the Federal study of the phosphate mining situation in central Florida." *Letter from Associate Director, Domestic Council, The White House, to Chairman, CEQ*, Apr. 7, 1976.

(By the time the referral was resolved, the referral regulations had been in place for over four years.)

CEQ action: From the time of the referral (12/31/74) until its resolution (1/14/83) the Council participated in many discussions and meetings regarding the proposal. The Council contracted a study for a national phosphate policy and Council legal staff did a legal analysis on the subject of leasing for mining. (The files indicate that the subject study on a national policy was completed only in draft form.) CEQ also participated in the legislative process from time to time regarding bills introduced to resolve the complex issues related to the proposal.

final CEQ action date: April 22, 1982.

result: As a result of legal and scientific studies, on January 10, 1983 the Secretary of the Interior announced his decision to reject the applications for preference right leases to mine phosphate in the Osceola National Forest.

At the same time, after years of consideration of legislation of the subject, the 97th Congress had passed a bill (H.R. 9, 97th Cong., 2nd Sess. [1983]) designating the subject areas as components of the National Wilderness Preservation System. The bill specified that the "Department of the Interior shall not issue phosphate leases in the Osceola National Forest, Florida, unless and until the President transmits a recommendation to the Congress that phosphate leasing be permitted in a specified area in the Osceola National Forest." (H.R. 9, Sec. 4, *infra.*).

Because the President believed the Secretary's action resulted in the same effect as the main purpose of the enrolled bill, and because the bill included a provision which the President perceived would cause unnecessary costs to the Federal taxpayer, the President vetoed the bill.

(*NOTE*: The bill included monetary compensation to applicants for release of preference rights held to mine the land, plus a right to applicants to petition in the United States Claims Court.)

epilogue: A bill was later passed in the 98th Congress designating the subject areas as components of the National Wilderness Preservation System, and consequently making any mining for minerals illegal.

Proposed Oil and Gas Lease Sale for the Northern Gulf of Alaska (#39)

proposal: Sale of 1.8 million acres of oil and gas leases in the Gulf of Alaska Outer Continental Shelf.

lead agency: Department of the Interior.

referred by: Environmental Protection Agency (EPA).

referral date: December 18, 1975.

referral basis: "EPA has determined that the proposed action as presently scheduled is unsatisfactory from the standpoint of environmental quality, based on its potentially harmful effects on the environment and on the fact that potential operational and technical safeguards which might be utilized may not adequately protect the environment from hazards arising from this action." EPA advocated delaying the sale until environmental baseline studies could be completed in the Gulf of Alaska, and Operating Orders could be formulated by appropriate federal agencies and other interested parties. *Referral Letter from Administrator, EPA, to Chairman, CEQ, December 18, 1975.*

national importance: NOTE: When this proposal was referred to the Council, the August 11, 1977 CEQ Interim Guidance had not been issued and the CEQ Regulations had not been promulgated. Section 309 of the Clean Air Act (42 U.S.C. 7509 [1970]) and Section 1500.9(b) of the CEQ Guidelines (38 *Fed. Reg.* 20555 [1973]) called for referral to CEQ, by EPA, of certain matters determined to be unsatisfactory from the standpoint of public health or welfare or environmental quality. The Interim Guidance, which was superceded by Part 1504 of the CEQ Regulations, set procedure and established criteria (including national importance) for referring a proposal.

CEQ action: CEQ staff met with representatives of the Department of the Interior, Environmental Protection Agency, the Federal Energy Administration, the Office of Management and Budget and the National Oceanic and Atmospheric Administration, to review the objections raised in the referral. Special emphasis was directed towards an understanding of the environment of the Gulf of Alaska Outer Continental Shelf, on the proposed U.S. Geological Survey Operating Orders, and on the probable onshore impacts that would be triggered by a lease sale.

final CEQ action date: February 25, 1976.

result: In a letter dated January 23, 1976, the Acting Chairman of CEQ wrote the Secretary of the Interior that, "We believe it would be most desirable, from an environmental point of view, to delay the sale for a sufficient period of time to permit substantial realization of the above set of benefits. We recommend that you give careful consideration to that option. The Council recognizes,

of course, that the final decision is yours and that you must decide whether the environmental benefits gained by such delay outweigh the costs of postponing potential oil and gas production and revenues. If, on balance, you conclude that a blanket delay of the sale is not in the national interest, the Council strongly urges that the sale be limited to those tracts that, relative to other tracts in the original proposal, appear to represent the lowest possible degree of risk of environmental damage." The letter included other specific recommendations and comments.

The Secretary of the Interior decided to proceed with the sale as scheduled. He reduced the amount of acreage to be offered for leasing from 1.8 million acres to 1.1 million acres, stating that the most risky tracts had been removed, that the remaining overall probability of damaging accidents was low, and the potential value to the nation of discoveries in the area was very high. *Letter from the Secretary of the Interior to the Chairman of CEQ*, February 17, 1976. He rejected CEQ's suggestion of a sale limited to .15 million acres. On February 25, 1976, CEQ sent a letter to the Secretary expressing disappointment with his decision. The Council stated, "[I]n our view, the OCS program for the Northern Gulf of Alaska has not progressed to the point where the information is adequate for making sound leasing decisions or conducting operations beyond the limited area we recommend and under the most tightly controlled conditions."

Upon receipt of new information, the Secretary withdrew additional acreage from the lease sale on April 6, 1976. The remaining 189 tracts (approximately one million acres) were offered for sale on April 13, 1976. Of eighty-one bids, the Secretary accepted bids for 76 of the tracts, comprising approximately 410,000 acres.

epilogue: The State of Alaska moved to enjoin the sale on the grounds that the lease sale violated NEPA; however, both the district court and the court of appeals denied the injunction and the lease sale proceeded as planned. Thereafter, the case was submitted on the merits to the district court, which then dismissed the complaint. In that decision, *State of Alaska v. Andrus*, 580 F.2d 465 (D.C. Cir. 1978), the Court of Appeals held that the Secretary of the Interior was not required to wait for results of ongoing environmental studies before making his decision to proceed with the lease sale, confirming his discretion to reject the advice of CEQ, EPA, and others to delay the sale, as long as he gave "full and careful consideration" to the alternative of delay.

However, the court found that the analysis of the proposed Operating Orders in the EIS for Sale #39 was inadequate. The EIS simply described the proposed Orders and adopted them, without any evaluation of their environmental impact or

alternatives to them. The court thought this a particular critical error since the Secretary's decision to proceed with the lease sale without delay was based on the premise of the Operating Orders. Thus, the court required the Department of the Interior to promptly reconsider the Operating Orders in an EIS, which presented an evaluation of reasonable alternatives.

Marco Island, Florida

proposal: To grant Corps of Engineers dredge and fill permits for a proposed Marco Island development which would be a water-oriented, retirement, second-home community and resort center. The 8,000 acre island lies in the northern end of the Ten Thousand Island chain in Southwest Florida, ten miles south of Naples.

lead agency: Corps of Engineers, Department of the Army.

referred by: Environmental Protection Agency.

referral date: March 15, 1976.

referral basis: Major concerns: destruction of approximately 2,200 acres of highly productive mangrove habitat, alteration and degradation of 735 acres of productive bay bottom, and general degradation of the physical, chemical and biological aspects of water quality.

national importance: Note: At the time that this proposal was referred to the Council, the August 11, 1977, CEQ Interim Guidance regarding the referral process had not been issued and the CEQ regulations had not been promulgated. Section 309 of the Clean Air Act (42 U.S.C. 7609) and CEQ Guidelines (38 *Fed. Reg.* 20550) called for referral to CEQ certain matters determined to be unsatisfactory from the standpoint of public health or environmental quality.

The Marco Island referral does not have a specific discussion of this issue in CEQ/EPA documents. In the press release announcing the decision on Marco Island permits, the Chief of Engineers said, "that there are overriding national factors of the public interest, and that the proposed filing of these mangrove wetlands would 'constitute an unacceptable adverse impact on this aquatic resource.' " (News Release, 4/16/76)

CEQ actions: CEQ had apparently been involved in the project prior to the date of the referral, including representation on a site visit in 1975 sponsored by the Corps. No formal response to the referral is in the file. The final letter refers to careful review of the facts and documents in this case.

final CEQ action date: May 1, 1976.

result: On April 16, 1976, the Chief of the Corps of Engineers denied the two permits which covered the largest area and dispute and granted a third permit.

CEQ concurred with the decision, in letters to both the Environmental Protection Agency and the Department of the Army.

EPA withdrew its determination that the proposal was environmentally unsatisfactory, despite reservations about the third permit (for which they recommended special mitigation measures).

Kaiparowits Power Project Southern Utah

proposal: The Arizona Public Service Company, San Diego Gas and Electric Company and Southern California Edison Company proposed to construct and operate a 3,000 megawatt, coal-fired, electric generating station and related facilities on the Kaiparowits Plateau in Southern Utah.

lead agency: Bureau of Land Management, Department of the Interior.

referral by: Environmental Protection Agency.

referral date: June 4, 1976.

referral basis: The EPA believed that: (1) the Department of the Interior would violate its own substantive environmental requirements by not utilizing its statutory responsibilities to protect National Parklands from degradation; (2) the significant environmental degradation which could occur if the project were constructed could be mitigated by other feasible alternatives. Major impacts would include air quality degradation; high levels of mercury in lake sediments; degradation of National Park areas; inadequate examination of alternatives. EPA recommended that approval of the project be denied unless the issues of concern were satisfactorily resolved and alternatives to the project which would be less environmentally harmful were considered.

national importance: NOTE: At the time that this proposal was referred to the Council, the August 11, 1977 CEQ Interim Guidance regarding the referral process had not been issued, and the CEQ Regulations had not been promulgated. Section 309 of the Clean Air Act (42 U.S.C. 7609) and CEQ Guidelines (38 *Fed. Reg.* 20550) called for referral to CEQ certain matters determined to be unsatisfactory from the standpoint of public health or welfare or environmental quality.

EPA's letter notes that many of the adverse environmental impacts associated with the proposed Kaiparowits project would be common to the other power plants being considered in the Southwest, but that the impacts of those power plants proposed to be sited in the canyon lands of southern Utah would be of special concern to the nation because of the value of the area as a scenically unique national asset.

CEQ actions: Shortly before the referral of the project to CEQ, the applicants announced cancellation of the project. Although EPA recognized this, the Administrator believed it was his responsibility to refer the matter because the permit application had not yet been formally withdrawn. CEQ's reply indicated that the applicants were in the process of preparing new submittals and that before, "we formally respond to your criticisms of June 4, 1976, it would appear wise for CEQ to review the current proposals of the applicants. For that reason CEQ will temporarily defer response to your referral pursuant to Section 309 of the Clean Air Act."

final CEQ action date: July 9, 1976.

result: Applicants cancelled project.

epilogue: Permit applications were officially withdrawn shortly after the referral in 1976. No new applications have been submitted since that time.

Westside Highway (Westway), Manhattan, New York City, New York

proposal: Highway project with interrelated urban developments involving dredge and fill in Hudson River.

lead agency: Federal Highway Administration, US-DOT.

referral by: Environmental Protection Agency.

referral date: February 14, 1977.

referral basis: EPA held that, although a replacement for the defunct Westside Highway in some form is needed, construction of Modified Outboard alternative is not the best solution: (1) incompatible with achievement of health-related National Ambient Air Quality Standards; (2) conflicts with objectives in State Implementation Plan to achieve air quality standards; and (3) inconsistent with the long-range transportation goals and needs of the city. EPA recommended a revised version of the preferred alternative.

national importance: NOTE: When this proposal was referred to CEQ, the August 11, 1977 CEQ Interim Guidance relating to a referral process had not been issued, and no CEQ Regulation had been promulgated. Section 309 of the Clean Air Act (42 U.S.C. 7609) and CEQ Guidelines (38 *Fed. Reg.* 20550) called for referral to CEQ of certain matters determined to be unsatisfactory from the standpoint of public health or welfare or environmental quality. Hence, the issue of national importance was not subject to evaluation.

CEQ actions: CEQ held meetings with DOT and EPA to discuss the issues. On April 18, 1977, CEQ requested from EPA additional information about air quality issue. EPA responded to CEQ's request May 26, 1977.

final CEQ action date: July 29, 1977.

result: "The Council has carefully reviewed your request that DOT should prepare a new air quality analysis which would take account of possible increases in traffic resulting from the improved highway. We have been cautious in our response because EPA's request was made in the last days of an extended review period for the final environmental impact statement, after several years of discussions between EPA and highway officials. Although we have agreed with EPA that the impact statement did not adequately consider the possibility that the proposed highway would stimulate increased traffic, we have not been provided with any evidence that the increase in traffic would create significant air quality impacts. Lacking such evidence, we do not believe that it would be reasonable to request DOT to undertake a new study of this matter at the conclusion of the review process." *Letter from Chairman, CEQ, to Administrator, EPA.*

epilogue: The Corps of Engineers issued, in April 1977, a public notice of an application for a permit to fill in the Hudson River for the Westway project. After much study, the Corps, on March 13, 1981, issued the permit over the objections of resource agencies. Note that the major issue then regarding permit issuance was project impact on Hudson River's striped bass resource, an impact unknown at time of CEQ referral in 1977.

Citizen and environmental groups sued in January 1982 to stop the project. In March 1982, the District Court ruled the permit invalid and directed that a supplemental EIS be prepared concerning impacts to the striped bass.

In May 1984, a draft supplemental EIS was issued jointly by the Corps of Engineers and the Federal Highway Administration.

A final statement was issued in November 1984. Interior, EPA, and Commerce (NOAA) indicated that the striped bass issue may be of sufficient national significance for a CEQ referral if Corps gives notice that permit for preferred "Outboard" alternative would be approved.

On February 22, 1985, the District Engineer, Corps of Engineers, issued dredge and fill permit. Resolution of Court filed in 1982 now pending.

Lake Alma, Georgia

proposal:	To construct Lake Alma, a man-made 1,400 acre lake in Bacon County, Georgia, funded by the Department of Housing and Urban Development (CDBG grant).
lead agency:	Department of Housing and Urban Development.
referral by:	Environmental Protection Agency.
referral date:	March 24, 1977.
referral basis:	EPA referred the proposal because of questionable water quality of the lake to be created and the destruction of 1,400 acres of bay branch swamp wetlands.
national importance:	NOTE: At the time that this proposal was referred to the Council, the August 11, 1977 CEQ Interim Guidance had not been issued and the CEQ regulations had not been promulgated. Section 309 of the Clean Air Act (42 U.S.C. 7609) and CEQ Guidelines (38 *Fed. Reg.* 20550) called for referral to CEQ of certain matters determined to be unsatisfactory from the standpoint of public health or welfare or environmental quality.

Both the EPA referral letter and CEQ's letter to the local officials recommending that the proposal be withdrawn, stress the idea that creation of the lake would contravene national policy regarding protection of the nation's wetlands. Further, CEQ concluded that the proposal is contrary to sections of NEPA which state congressional goals for the federal government to "attain the widest range of beneficial uses of the environment without degradation," to "preserve important historic, cultural and natural aspects of our national heritage," and to "achieve a balance between population and resource use which will permit high standards of living and a wide sharing of life's amenities. . . ." EPA then asked CEQ to chair an interagency review team to study many of the issues examined in the EIS.

CEQ actions: The Governor of Georgia asked EPA to delay referral until an independent team assembled by EPA and acceptable to the state completed its review of the Lake Alma project; EPA declined to do so. The Council believed that such a review would not be helpful, and that the proposal violated national policies to preserve wetlands (NEPA, EO, etc.) and would be an inappropriate use of federal funds. A site visit was conducted by a staff biologist and discussions with outside parties were held.

In a letter from the Chairman of CEQ to the Secretary of Housing and Urban Development, CEQ recommended that HUD: (1) notify the applicant that it should now reprogram funds and (2) advise the applicant that if it wished, it could obtain assistance from HUD or other agencies to plan other methods to achieve economic development. In a letter to the Mayor of Alma and Chairman of Bacon County, CEQ set out the basis for its determination that the Lake Alma project should not be funded by HUD.

final CEQ action date: June 10, 1977.

result: HUD decided not to release funds in August 1977.

epilogue: The new administration determined to reverse the position taken not to fund the project, and okayed funding of this project. A 404 permit was needed from the Corps of Engineers. This engendered further controversy, and EPA challenged the 404 permit. CEQ was involved in EPA's initial decision to recommend elevation of the 404 permit decision to the Washington level. In a letter dated October 9, 1981, the Administrator of EPA informed the Corps of Engineers that the EPA questions regarding the loss of wetlands and the water quality of Lake Alma had been adequately answered, and that EPA now withdrew its objections to the project. The Corps issued the permit, along with a mitigation plan. Litigation ensued, and in *National Wildlife Federation v. Marsh*, 721 F.2d 767 (11th Cir. 1983), the Eleventh Circuit Court of Appeals held, *inter alia*, that the municipality must prepare a supplemental EIS on the mitigation plan. The NWF has filed a petition challenging the holding which is concerned with HUD's authorization to fund the project, due to changes in the relevant statute.

Wando and Cooper Rivers (Permit, Dredge, Construction of a Marine Terminal) Charleston County, South Carolina

proposal: The Army Corps of Engineers proposed to grant a 404 permit to build a marine terminal at the mouth of the Wando River in a relatively pristine area including undeveloped wetlands.

lead agency: Corps of Engineers, Department of the Army.

referral by: Environmental Protection Agency.

referral date: April 20, 1977.

referral basis: EPA's concerns were submitted by their April 20, 1977 letter to the Corps of Engineers. The following quote expresses the reasons for the referral:

> "The cumulative adverse environmental impacts from runoff, oil spills and industrial development will result in severe deterioration of the water quality of the Wando River, and of the surrounding wetlands ecosystem. Of particular concern is the contamination of a productive river by port construction activities, and damage to the river's biotic system by port operations; the direct loss of thirty acres of Priority I marsh; and the threatened contamination of an additional thousand acres of Priority I marsh due to secondary development. We believe that secondary development is directly related to the construction of the marine terminal, and will increase severalfold the environmental impacts of the terminal alone."

national importance: NOTE: At the time that this proposal was referred to the Council, the August 11, 1977 CEQ Interim Guidance on Referrals to The Council of Proposed Federal Actions Found to Be Environmentally Unsatisfactory had not been issued and the CEQ Regulations had not been promulgated. Section 309 of the Clean Air Act (42 U.S.C. 7609) and 1973 CEQ Guidelines (38 *Fed. Reg.* 20550) called for referral to CEQ certain matters determined to be unsatisfactory from the standpoint of public health or welfare or environmental quality but did not refer specifically to "national importance." The Wando & Cooper River Referral does not have specific discussions of national importance.

CEQ action: The Council agreed with EPA that the Corps had not adequately analyzed other alternatives and recommended further analysis.

final CEQ action date: December 21, 1977.

result: The Corps conducted further analysis and concluded that there were no other suitable sites. Acting on the recommendations of CEQ and EPA, the Corps modified the proposal by attaching conditions to the permit to mitigate adverse impacts and to protect certain areas from development.

Packer River Terminal – Barge Terminal Expansion, Dakota County, Minnesota

proposal: Packer River Terminal, Inc. sought federal permits to expand a

barge terminal facility on the Mississippi River involving the filling of approximately 23 acres of wetlands.

lead agency: Corps of Engineers, Department of the Army.

referral by: Environmental Protection Agency.

referral date: January 11, 1978.

referral basis: EPA referred the proposal because of the adverse impacts of wetlands, the potential availability of alternative sites, and the violation of Section 404 guidelines and regulations (according to EPA).

national importance: "The proposed expansion of the barge terminal is of national concern because it is contrary to the spirit of President Carter's Executive Order on Wetlands; EPA's Section 404(b) of the Federal Water Pollution Control Act (FWPCA) guidelines; the EPA Administrator's Decision Statement on Wetlands Protection; and the Army Corps of Engineers Section 404 regulations." *Referral Letter from Administrator, EPA, to Chairman, CEQ,* January 11, 1978.

"Upon the Corps' completion of this analyses of alternatives, we believe that its decision on whether to issue a permit for expansion of the Packer Terminal does not constitute a nationally significant environmental matter warranting CEQ's intervention in the Corps/EPA decisionmaking process under Section 404.

"We have reached this conclusion because

- The proposed project is located in an industrial area classified as an 'Urban Diversified District' under the Minneapolis-St. Paul metropolitan Critical Areas Program for the Mississippi River.

- State, regional and local permits have been obtained for the project following what appear to have been adequate consideration of wetlands and other environmental impacts.

- The Federal Fish and Wildlife Service has agreed to issuance of the Section 404 permit, conditioned on specified mitigation and dedication measures.

- Air quality impacts will be evaluated in the future by the Minnesota Pollution Control Agency after the applicant has determined the types of commodities to be served by the proposed terminal and after the MPCA has analyzed their air pollution impacts.

- We have no evidence of public opposition to the project.

- As long as the Corps complies with the requirements of Section 404 and the Corps' wetlands policy, there would not appear to be a violation of the spirit of the wetlands Executive Order if a permit ultimately issues in this case."

Letter from Senior Staff Member, CEQ, to Deputy Director of Civil Works, Corps of Engineers, April 18, 1978.

CEQ action: On February 1, 1978, CEQ wrote to the Corps, informing them of the referral and requesting the Corps to inform CEQ of its plans with respect to the referral — i.e., how and when Corps would respond. This was followed by CEQ meeting with EPA staff (March 22, 1978) and Corps staff (March 27, 1978). CEQ requested additional information from EPA regarding EPA's concerns.

final CEQ action date: April 14, 1978.

result: Upon analysis of EPA's information and the proposal itself, CEQ determined that the Corps should further analyze alternative sites and upon completion of the analyses the proposal would not warrant CEQ intervention.

epilogue: The applicants (Packer River Terminal, Inc.) brought suit, but the court dismissed the case. The Corps issued the 404 permit, and the wetlands were filled. The PRT subsequently went bankrupt and no action has been taken to build on the site.

County Trunk Highway "Q," Kenosha, Wisconsin

proposal: County Trunk Highway "Q" — to add a 1.94-mile link to road system.

lead agency: Federal Highway Administration, Department of Transportation.

referral by: Environmental Protection Agency.

referral date: December 9, 1977.

referral basis: Main point was that over 60% of the route would traverse prime quality marshes and wetlands which were the principal northern pike spawning areas for the Des Plaines River. EPA saw the proposal as an incremental destruction of wetlands which, in turn, would result in further development of wetlands in the area.

national importance: In its referral letter of December 9, 1977, to Secretary of DOT, EPA stated: "Wetlands are a resource of national concern, and

the environmental impacts of piecemeal encroachments upon them must be viewed in that context."

Shortly thereafter, a senior CEQ staff member sent a memorandum to EPA, requesting a supplemental memorandum that addressed the issue of national significance since it was not covered in the initial referral from EPA to CEQ. At the same time, CEQ asked US-DOT to address this subject in its response. Also see next two items.

CEQ action: Although CEQ expressed shared concern over wetlands destruction, the Council declined to make a recommendation to DOT because of the local nature of the referral and the fact that EPA had an adequate review mechanism through its 404(c) veto authority.

final CEQ action date: February 1, 1978.

result: EPA's regional administrator wrote to the Corps indicating EPA's intention to veto a 404 permit if granted. (EPA understands that CEQ may continue to decline to make recommendations in similar referral situations; CEQ also urged EPA to develop 404(c) procedures.)

epilogue: Because of the wetlands involvement and interrelated 404 permit problems, the project was dropped. Current indications are that there is no intent to revive it.

Foothills Reservoir, Denver, Colorado

proposal: Denver wished to increase its water supply in response to projected needs for 1990 and to increase water available for current summer use by building a reservoir in the foothills south of the city. Right-of-way permits were needed from the Bureau of Land Management to cross 51 acres of land, and from the Forest Service to cross 43 acres of land.

lead agency: Bureau of Land Management, Department of the Interior.

referral by: Environmental Protection Agency.

referral date: January 17, 1978.

referral basis: EPA determined that the proposal was unsatisfactory because of concerns that construction of the project would make the attainment and maintenance of national air quality standards "more difficult and perhaps impossible," and would result in significant

degradation to aquatic, wildlife and recreational resources. *Referral letter from Administrator of EPA to Chairman of CEQ*, March 9, 1978.

national importance: "The national environmental standards for air quality are currently being violated in the Denver metropolitan area on a regular basis as pointed out previously. Over 1.5 million people living within the Denver air basin are subjected to the pollution. . . . The necessary reduction in VMT [vehicle miles traveled] may be impossible to achieve if continued low density urban sprawl is made possible and facilitated by the construction of the Foothills Project. Clean air for public health and welfare is a national goal, and federal efforts should be coordinated to ensure that the goal is actively pursued.

"The nation is presently undertaking a massive effort to clean up our air. . . . At the very least, the federal government should be sure that its actions do not nullify the gains that the public is being asked to pay for." *Support Document for EPA's Determination that the Proposed Foothills Project Is Environmentally Unsatisfactory*, March 9, 1978.

CEQ actions: The Council agreed that the environmental impacts of the proposal were unacceptable because they would (1) encourage water consumption when Denver neither had a water conservation program nor seriously considered one as a full or partial alternative; (2) would encourage sprawl (although this might be better than higher density urbanization with respect to Denver's air quality problems); and (3) would increase pressure to take water from the Western slope farmers and national forests.

result: The Departments of the Interior and Agriculture issued the right-of-way permits with stipulations limiting the capacity to 125 mgd and requiring Denver to design and adopt a water conservation plan..

epilogue: The DWB then applied for and received a 404 permit for dredge and fill from the Army Corps of Engineers.

The 250 mgd project was completed in the early 1980s, and currently plans are being considered to expand the facility.

Fire Island to Montauk Point (Beach Erosion Control and Hurricane Protection Project) Long Island, New York

proposal: The Corps of Engineers proposed to rebuild the southern edge of Long Island by creating a 25′ × 16′ dune along 83 miles of barrier beach in order to slow the pace of erosion and shield developed and undeveloped areas from storm flooding.

lead agency: Corps of Engineers, Department of the Army.

referral by: Department of the Interior.

referral date: March 7, 1978.

referral basis: The Department of the Interior referred the proposal in accordance with the Council's Interim Guidance of August 11, 1977. In its referral letter Interior wrote:

"This project is the largest barrier beach modification proposal to date. It will result in serious and irrevocable adverse impacts on the natural resource values of this barrier island and beach with National precedent setting potential to other barrier beach ecosystems. Further, this proposal is in conflict with the Congressional authorization establishing Fire Island National Seashore."

The referral was supported by the Department of Commerce.

national importance: "As we stated in our June 4, 1976 letter, 'Public Law 88-587 authorized and established the Fire Island National Seashore. . . for the purpose of conserving and preserving for the use of future generations certain relatively unspoiled and undeveloped beaches, dunes, and other natural features within Suffolk County, New York, which possess high values to the Nation as examples of unspoiled areas of great natural beauty in close proximity to large concentrations of urban population. . . .

. . .

"The project conflicts with the main purposes [of the Act], to protect and preserve the flora and fauna of the dune ecosystem, for which the Amagansett National Wildlife Refuge is a part of.

. . .

"The impacts of this project as proposed will result in degradation of a Nationally significant environmental resource." *Referral letter from Acting Secretary of the Interior to the Chairman of CEQ*, March 7, 1978.

"The Fire Island National Seashore, for example, which comprises nearly a third of the project area and is located on the western end of the system, is likely to be affected by any major shoreline changes to its east. This relationship gives us special cause for concern in light of the intention of the Congress and the National Park Service to allow the National Seashore to revert to as natural a state as possible." *Letter from Chairman, CEQ, to Chief of Engineers, Corps*, June 6, 1978.

"The impact statement recognizes that the project will spur development of the barrier beach and mainland coast, much of which is adjacent to the National Seashore, but it does not identify or analyze nonstructural alternatives to the project." *Attachment to June 6, 1978 Letter Cited Above.*

CEQ actions: CEQ initiated a meeting among the agencies participating in the proposal/referral. After the meeting the Council requested that both Interior and Commerce restate their views of the proposal.

final CEQ action date: June 6, 1978.

result: Both agencies reaffirmed in writing their concerns stating that the Corps' proposed remedy did not resolve those concerns. Upon review of Commerce and Interior's concerns and the proposal itself, CEQ agreed with the stated concerns and analysis of impacts of the proposal.

CEQ wrote the Corps noting that the Corps planned to start some actions without having a complete plan. This lack of planning would cause delays later. CEQ reminded the Corps that the Congress had legislated that the plan would have to be acceptable to the Secretary of the Interior. (16 U.S.C. 459e–7).

CEQ therefore recommended revision of the programmatic proposals and reanalysis of their impacts.

epilogue: There has been no alteration to the proposed site and the project under its original form has been dropped. However, there continues to be research into similar projects to solve the erosion and flooding problems.

In February 1978, a major coastal storm struck the Northeast, causing locally severe erosion and damage to parts of the southern shore of Long Island. There was substantial local, state, and congressional interest in developing a solution to the immediate problem, and the Department of the Interior became concerned that the Corps not implement an interim action which would adversely affect the natural ecosystem of Fire Island National Seashore or preempt a long-term solution to beach erosion in the area. The Department of the Interior asked CEQ to convene a meeting of interested agencies to secure interagency agreement on the interim action to be undertaken by the Corps of Engineers. CEQ held such a meeting on October 26, 1978, which resulted in agreement between the Corps, the Department of the Interior, the Environmental Protection Agency, and the National Oceanic and Atmospheric Administration regarding interim remedial action. The agreement specified that the remedial action would

be (1) limited to those areas for which it was essential; (2) designed and implemented in an environmentally responsible fashion; and (3) did not involve actions that are inconsistent with the reformulated project planning. *Letter from CEQ Executive Director to Director of Civil Works, Corps of Engineers*, January 18, 1979.

Central and Southern Florida Flood Control Project, Hendry County, Florida

proposal: The Central and Southern Florida Flood Control project in Hendry County was one of six segments of a massive drainage and flood control project for central and southern Florida, first envisioned in 1948. This segment of the project was proposed to prevent overdrainage and remove floodwaters from a large area southwest of Lake Okeechobee.

lead agency: Corps of Engineers, Department of the Army.

referred by: Department of the Interior.

referral date: March 9, 1979.

referral basis: The Department of the Interior believed that the project, as proposed, would cause "severe long-term adverse environmental effects on south Forida's wetland ecosystem," specifically affecting the Big Cypress Watershed and the Florida Everglades. Further, the Department stated that the proposal conflicted with the Executive Orders on Floodplain Management (E.O. 11988) and Protection of Wetlands (E.O. 11990), as well as the President's water resources project decision criteria. *Letter from the Secretary of the Interior to the Chairman of CEQ*, March 9, 1979.

national importance: "Congress has recognized the national importance of Everglades National Park and the Big Cypress Watershed. The final environmental impact statement fails to justify the risks due to project-induced changes, hydrological conditions and water quality in the Big Cypress Watershed and the Everglades National Park resulting from a project benefitting primarily 21 private landowners, predominantly agricultural development interests." *Statement of the U.S. Department of the Interior Concerning the U.S. Army Corps of Engineers' Central and Southern Flood Control Project, Hendry County, Florida*, March 9, 1979.

CEQ actions: CEQ held two meetings with the lead and referring agencies in Washington, D.C., and made a site visit and met with federal, state, and local officials in the area of the proposed project.

final CEQ action date: September 7, 1979.

result: The Corps of Engineers and the Department of the Interior mutually agreed to implement several actions to lessen the project's environmental impact, including building a shelf in the drainage canal and monitoring the discharges from the project. In addition, the State of Florida's Department of Environmental Regulation and the South Florida Water Management District provided assurances that their agencies would act to protect significant wetlands in the Hendry County project area from increased drainage as a result of the problem.

epilogue: The Corps of Engineers proceeded with water quality monitoring. However, the local community decided that the federal project was not needed, and it was not built.

Interstate 84 and I-84/I-86 Connector, Tolland and Windham Counties, Connecticut; and Providence County, Rhode Island

proposal: I-84 between Hartford, CT, and Providence, RI. (Section I — 12 miles; Section II — 22 miles).

I-84/I-86 Connector in Providence, RI.

lead agency: Federal Highway Administration, Department of Transportation.

referral date: December 13, 1979 (EPA).
December 28, 1979 (Interior).

referral basis: EPA held that the approved Section I of I–84 was a part of a larger plan in which environmental concerns with the not-yet-approved Section II in RI were unresolved.

EPA stated that construction of I–84 in CT would initiate an irreversible chain of events which would result in interstate traffic traversing the Scituate Reservoir and 14 miles of its watershed. The environmental issues centered around how this watershed might be seriously affected both by construction of I–84 in Rhode Island and/or by construction of only the Connecticut segment to the westerly boundary of the Scituate Reservoir. EPA cited the substantive and procedural requirements of NEPA, the CEQ regulations, and the DOT regulations. In sum, the relevant parts of the three legal authorities cited require that agencies examine the whole of a particular action, present the cumulative environmental impacts and alternatives, and that closely related proposals be evaluated in a single impact statement.

Interior noted additional major concerns re DOT-approved Section I of I-84 and the I-84/I-86 Connector (not an issue by EPA) and forecast an unacceptable loss of valuable streams, wetlands,

and upland fish and wildlife habitat. In addition to authorities cited by EPA, Interior cited E.O. 11990 – Protection of Wetlands. In a supplemental letter of January 9, 1980, Interior added criticism about treatment of potential hydrologic impacts.

national importance: "We believe that both segmentation and water quality issues evident in these Final EIS's should be considered of national significance." *Letter from Administrator, EPA, to Chairman, CEQ*, December 13, 1979.

CEQ actions: CEQ staff/Interior consultations resulted in Interior verbally agreeing that the I/84/I-86 project could be disassociated from its broader and more significant concerns about I-84.

CEQ staff was briefed on February 10, 1980, by US-DOT and Federal Highway Administration staff.

The Council later directed inhouse studies on (1) the legal issues of the referral and (2) the environmental issues with respect to the Scituate Reservoir and watershed. The studies confirmed the positions and concerns made by EPA and Interior regarding these two issues.

The CEQ's legal conclusions were that DOT: (1) approved location for I-84 in Connecticut and committed funds for design work before completing the NEPA process for I-84 in Connecticut; (2) had unreasonably limited the choice of alternatives considered for the Connecticut and Rhode Island segments of I-84; and (3) prematurely committed resources toward construction of I-84 along the conditional alignment in Connecticut.
The CEQ staff scientist concluded that "The construction and operation of I-84 in a central corridor through the watershed and across the reservoir system would adversely affect the quality of water in the Scituate Reservoir. In certain circumstances, the negative effects could be so severe or chronic as to force the curtailment or closure of the drinking water supply. The negative effects and the potentially severe or chronic effects would be caused by four general factors: highway construction; normal operation of the highway; accidents; and secondary development, such as residential or commercial development."

After these reviews and the review of extensive correspondence on the proposal, CEQ, on April 30, 1980, wrote DOT/FHWA stating the legal and environmental concerns while submitting copies of both inhouse reports.

"The Council has concluded that the proposed construction of I-84 across the watershed is environmentally unacceptable. It would violate sections 101(b)(2) and (3) of the National Environmental

Policy Act to 'assure for all Americans safe, healthful, productive . . . surroundings' and to 'attain the widest range of beneficial uses of the environment without degradation, risk of health or safety, or other undesirable and unintended consequences.' " *Letter from Chairman, CEQ, to Secretary of Transportation.*

final CEQ action date: April 30, 1980.

result: By letter of August 18, 1980, supplemented on October 17, 1980, the Secretary of Transportation committed to actions which would counter the concerns expressed by the CEQ, EPA, and Interior.

DOT informed the following: (1) the State of Rhode Island that FHWA would eliminate consideration of the I-84 route through the Scituate Reservoir, and (2) the State of Connecticut that DOT would not approve acquisition of land or construction on its portion of I-84 unless either: (a) a decision were made to proceed with construction of I-84 in Rhode Island following preparation and approval of an environmental impact statement; or (b) DOT was directed by Congress to do so.

epilogue: The I-84/I-86 Connector is presently under construction. This section was litigated in the U.S. District Court and the decision to allow full construction was upheld. Also, consultation among FHWA/Interior/Conn-DOT/Conn-DNP resulted in significantly better mitigation measures.

Both Connecticut and Rhode Island decided to abandon I–84 and in September 1983, the Secretary of Transportation: (1) approved withdrawal of I-84 from the National Interstate System and (2) consented to the use by both States of "interstate transfer funds" for substitute projects in the I-84 corridor.

Interstate 476, Mid-County Expressway, Delaware and Montgomery Counties, Pennsylvania

proposal: I-476, a quasi-beltway around Philadelphia.

lead agency: Federal Highway Administration, US-DOT.

referral by: Department of the Interior.

referral date: November 10, 1980.

referral basis: Major points made: expressway would largely eliminate open space, natural urban area amenities, and recreation values; 29

parks would be adversely affected; noise and air pollution levels would rise, often doubling; 8 sites on or eligible for the National Register of Historic Places would be adversely affected; major increases in flood state levels would result; a substantial amount of stream relocation would be required; wetlands may be lost; erosion and sedimentation would increase, biotic diversity would decrease; approximately one-third of a million trees would be removed.

Impacts would occur in a major and densely populated metropolitan area. Cites 4(f) concerns, as well as Executive Orders on Floodplains and Wetlands.

national importance: DOI recommended no build alternative. "The proposed Mid-County Expressway is incompatible with national policy as expressed in Section 4(f) and Executive Orders on Wetlands and Floodplains and, hence, is of national importance." (from DOI referral letter).

lead agency response: January 12, 1981.

CEQ actions: On February 12, 1981, CEQ met with the involved agencies. A large number of letters were received from the public on the issues involved. CEQ decided that consideration of alternative routes was satisfactory for purposes of NEPA, but identified three issues which it felt needed to be addressed: (1) mitigation of impacts to recreational lands affected by the project, (2) appointment of an environmental monitor to oversee the project design and construction, and (3) coordination with Swarthmore College on mitigation of impacts to that institution.

final CEQ action date: March 25, 1981 (letter from CEQ Acting Chairman, to Secretary of Transportation).

result: The FHWA prepared and executed on March 31, 1981, a Record of Decision which incorporated the three CEQ concerns detailed above. Although agreeable to resolution of the three mitigation concerns, Interior continued its objection, on section 4(f) grounds, to the project sponsor's consideration of all feasible and prudent alternatives.

epilogue: On November 12, 1981, Marple Township, Radnor Township, Swarthmore College, and Ashwood Manor Civic Association filed suit in Federal District Court to stop the project. The court declared on August 30, 1982, that although alternative considerations were adequate under NEPA, they were by no means adequate under Section 4(f). The court directed that a new Section 4(f) statement and a supplemental EIS be prepared. Project implementation was enjoined.

In August 1983, FHWA developed and circulated a new combined EIS/4(f) document for a scaled-down Blue Route aimed at meeting environmental and aesthetic objections. In its comments on the new document, the Department of the Interior continued its former objection to the project on Section 4(f) grounds.

FHWA approved the final supplemental EIS and Section 4(f) statement on April 9, 1984. Citizens again sued on August 16, 1984, to block construction.

On March 14, 1985, the U.S. District ruled in favor of defendants (US-DOT, FHWA, Penn-DOT) on all counts.

Jackson Hole Airport, Boeing 737 Service, Teton, Wyoming

proposal: Initiate Boeing 737 service at Jackson Hole Airport, Jackson, Wyoming.

lead agency: Federal Aviation Administration, Department of Transportation.

referred by: Department of the Interior and Environmental Protection Agency.

referral dates: January 9, 1981, Interior
January 9, 1981, EPA.

referral basis: Both agencies' primary environmental concern was the proposal's potential noise impacts on Grand Teton National Park.

The EPA made five recommendations starting with denial certification of Boeing 737 service to Jackson Hole Airport — the heart of the federal action, and ending with a recommendation that technical differences be resolved to establish a base for further planning and environmental studies related to Jackson Hole Airport and various alternatives.

Interior also recommended denial of the certification for Boeing 737 service into Jackson Hole Airport.

national importance: "Grand Teton National Park, by law and through its master plan has been given the highest category of protection available as an integral and irreplaceable part of the national park system. Therefore, the impacts of this proposal have significant implications not only to Grand Teton National Park itself, but also the National Park System in general." *Referral Letter from Administrator of EPA to Chairman of CEQ*, January 9, 1981.

"(b) . . . Congress further reaffirms, declares, and directs that the promotion and regulation of the various areas of the National Park System, as defined in section 2 of this Act, shall be consistent with and founded in the purpose established by the first section of the Act of August 25, 1916, to the common benefit of all the people of the United States. The authorization of activities shall be construed and the protection, management, and administration of these areas shall be conducted in light of the high public value and integrity of the National Park System and shall not be exercised in derogation of the values and purposes for which these various areas have been established, except as may have been or shall be directly and specifically provided by Congress." 92 Stat. 166, P.L. 95–250, Mar. 27, 1978. An Act to amend the Act of Oct. 2, 1968, and Act to establish a Redwood National Park in the State of Calfiornia, and for other purposes.

CEQ actions: Upon receipt of referral, CEQ staff promptly initiated discussions with DOT/FAA leading to the draft revised record of decision. Secretary of the Interior wrote CEQ on January 16, 1981, concurring to the terms of draft revised record of decision. On this date, CEQ advised EPA how referral was being resolved.

final CEQ action date: January 19, 1981.

result: Revised record of decision was approved by Secretary DOT and accepted by Interior and EPA.

epilogue: DOT's decision to allow 737 service to Jackson Hole was challenged in federal court by the Sierra Club in March of 1981. The DC Court of Appeals found in favor of DOT on March 3, 1982.

On November 2, 1982, the Secretary of the Interior reversed an August 22, 1979 decision by his predecessor and declared the Jackson Hole Airport necessary for the proper performance of the functions of the Department of the Interior.

On January 31, 1983, DOT renewed and made permanent 737 service to Jackson Hole. Most of the conditions (except three conditions dealing with noise) placed on the 1981 approval were omitted in the 1983 decision. The Sierra Club again sued DOT, and the court again found in favor of DOT.

A new management agreement between NPS and the Jackson Hole Airport Board was signed on April 27, 1983. This new agreement included noise controls, but omitted any mention of planning for eventual airport relocation.

The Sierra Club now sued Interior re the new management agreement which effectively extended the life of the airport at its

present location within Grand Teton National Park until year 2013, and probably for an indefinite time thereafter. Case presently pending before the courts. In the meantime, 737 service to Jackson Hole Airport has been ongoing since June 1, 1981.

Elk Creek Dam, Rogue River, Oregon

proposal: Elk Creek Reservoir on the Rogue River Basin, Oregon.

lead agency: Corps of Engineers, Department of the Army.

referral by: Department of the Interior.

referral date: January 19, 1981.

referral basis: Major concerns of the Department of the Interior included: significant adverse effects on nationally renowned steelhead trout and chenook salmon; inundation of 1,290 acres of mixed conifer, oak, meadow and riparian wildlife habitat; loss of wetlands; conflicts with NEPA policies.

CEQ actions: On April 2, 1981, CEQ wrote to the Department of the Interior, asking for responses to several questions to clarify points raised in the referral letter. On April 3, 1981, CEQ wrote the Secretary of the Army, identified three principal issues in dispute (water quality, flood damage reduction, benefit-cost analysis), and asked the Army to respond promptly to a number of questions about each issue.

withdrawal: On April 2, 1981, the new Under Secretary of the Department of the Interior wrote to the Director of Civil Works for the Army and stated that all previous comments about the Elk Creek Reservoir Project were being withdrawn, pending further reconsideration. A press release announcing this development was issued by the Department of the Interior on April 3, 1981.

epilogue: On April 17, 1981, CEQ acknowledged the actions of the Department of the Interior in a letter to the Department of the Army. Because of concerns expressed by other parties, however, CEQ asked the Army to respond to the questions listed in the letter of April 3, 1981.

In July 1981, the Secretary of the Interior withdrew the referral to CEQ.

On August 20, 1981, the Department of the Army submitted to CEQ answers to the questions raised in the April 3, 1981, CEQ letter.

Dickey-Lincoln School Lakes Projecct, St. John River, Maine

proposal:	Construction of Dickey-Lincoln School Lakes Dam on St. John River in northern Maine.
lead agency:	Corps of Engineers, Department of the Army.
referral by:	Department of the Interior.
referral date:	September 28, 1981.
referral basis:	DOI stated that project-induced losses would include the large-scale destruction of terrestrial and aquatic resources and the elimination of an important wilderness recreational area, and that mitigation for these losses had not been adequately addressed. Further, they stated that the FEIS did not address alternatives which would allow development of the hydroelectric potential of the St. John River basin while maintaining its unique natural resource and recreational value. DOI recommended that: (1) The Corps withdraw its EIS and that the Corps, DOI, and other appropriate agencies work together to develop a plan which preserved the resource and recreational values of the St. John while providing hydroelectric power; (2) the President recommend amendment of the project authorization as needed to accomplish the above goals and to provide for appropriate mitigating measures.
national importance:	DOI: "The project as proposed will result in degradation of a nationally significant environmental resource. Project-induced losses include the large-scale destruction of terrestrial and aquatic resources, and elimination of an important wilderness recreational area."
CEQ actions:	CEQ initiated staff discussions and recommended to OMB that the Administration recommend that the entire project be deauthorized.
final CEQ action date:	November 24, 1981.
result:	Senator Cohen introduced S. 1439 deauthorizing the project. This bill passed and the project was deauthorized.

Palmdale International Airport, Palmdale, California

proposal:	Funding and approval of Palmdale International Airport, Los Angeles County, California.

lead agency: Federal Aviation Administration, Department of Transportation.

referral by: Department of Defense (U.S. Air Force).

referral date: August 31, 1982.

referral basis: "Our two basic environmental concerns are (a) the serious safety hazard created by the co-existence of necessary military air operations and numerous civilian flights in confined airspace, and (b) the impact on land use of the adjoining and nearby military facilities by arriving and departing flights from PIA." *Letter from Deputy Secretary of Defense to Chairman, CEQ*, August 31, 1982.

national importance: "The Department of Defense is of the opinion that ignoring the issue of airspace conflicts and attendant consequences to the land uses dependent on airspace is not satisfactory where the public welfare and national defense are concerned." *Statement accompanying referral letter*, August 31, 1982.

CEQ actions: CEQ informed the FAA of the referral and the requirements for the lead agency's response on September 2, 1982, and subsequently, CEQ staff met once with the Air Force for an initial briefing on the issues.

On September 9, 1982, the Administrator of the FAA requested an indefinite extension of the response time to the referral from CEQ, with the assurance that no FAA action described in the Final EIS would go forward during the extension period. CEQ granted this request on September 16, 1982. On October 21, 1982, the FAA Administrator, in a letter to the Chairman of CEQ, stated that following a meeting between the FAA and the Air Force at Edwards Air Force Base, a joint FAA/DOD team was developing a plan which would "accommodate the needs of our respective agencies." In the meantime, the Administrator again assured CEQ that the FAA would take no action to implement the Palmdale project until the differences were resolved.

Presidential Parkway, Atlanta, Georgia

proposal: A 2.4 mile Parkway in Altanta, adjacent to a Presidential Library.

lead agency: Federal Highway Administration, Department of Transportation.

referral by: Advisory Council on Historic Preservation.

referral date: June 25, 1984.

referral basis: The proposed Parkway would be adjacent to several historical

districts and a series of parks designed by Frederick Law Olmsted (and would take a very small portion of the park area). Major issues of concern raised by the referring agency were: (1) the effect of the proposal on the Olmsted parks and historic neighborhoods; (2) other alternatives which could potentially address transportation needs; (3) the question of whether the proposed Parkway was a segment of a more ambitious highway proposal; (4) whether it was appropriate to fund a project which would compete with mass-transit (MARTA); (5) the question of regional versus local needs in public land use.

national importance: CEQ specifically asked for written comments from both government agencies and the public on the question of "national importance," and thus a number of viewpoints about this issue were communicated to CEQ. Although other issues were raised, the overwhelming number of comments focused on the Olmsted parks, and, concomitantly, nearby historic properties and neighborhoods, and whether these were of national importance and/or whether the proposal would have significant adverse impact on them.

CEQ actions: At a public meeting held on July 7, 1984, CEQ decided to address specifically the issue of national importance in relationship to this referral. In a *Federal Register* notice published July 24, 1984, CEQ asked for written comments from the public on this issue. 49 *Fed. Reg.* 29,812 (1984). The comment period closed on August 24, 1984. Additionally, CEQ Council Members met individually with interested parties in both the private and public sector and made independent visits to the site of the proposed parkway.

final CEQ action date: September 20, 1984.

result: CEQ determined that the referral did not raise an issue of national importance. In a statement published in the *Federal Register*, the Chairman and a Member stated, "We recognize that the referral raises concerns which are cognizable under NEPA, notably, the preservation of historic resources. However, we do not believe that the context and intensity of these issues rise to the level of 'national importance.' We do not believe that the referral raises new, precedent making issues which are reasonably likely to affect national policies in the environmental arena. Nor do we find the level and intensity of controversy attendant to this proposed project to be so unique in the realm of public works projects that it warrants our review under the national importance provision. . . . We regret the slight taking of the parkland which would occur should the Parkway be constructed, but we do not feel that this loss is one which is of

national importance. Further, we do not perceive any nationally important adverse environmental impacts which would be likely to occur as a result of the Presidential Parkway's construction."

In a separate statement, the third Council Member stated, "In my view, a design can be altered in its details, including changes in its use, yet retain fundamental integrity. Information presented to the Council persuades me that the design and operational aspects of the Presidential Parkway represent a significant attempt to preserve the integrity of the original design while adapting it to later needs. . . . I cannot determine that *any* alteration of the original landscapes must necessarily be of national importance, nor can I determine that the preservation of the Olmsted legacy requires that no changes in the design or use may be tolerated." 49 *Fed. Reg.* 37,657 (1984).

epilogue: Plaintiffs were not successful on environmental (including NEPA) and historic grounds in district court. *Druid Hills et al. v. the Federal Highway Administration, et al.* An appeal is pending before the United States Court of Appeals for the Eleventh Circuit.

Tennessee-Tombigbee Waterway Wildlife, Mitigation Feasibility Study, Alabama and Mississippi

proposal: Mitigation Plan regarding construction of the Tennessee-Tombigbee Waterway in Alabama and Mississippi.

lead agency: Corps of Engineers, Department of the Army.

referral by: Department of the Interior.

referral date: December 28, 1984.

referral basis: The Department of the Interior was concerned about the "severe long-term environmental impacts as a result of construction of the TTW, including the destruction of approximately 34,000 acres of forested wetlands." The Department was concerned that the Corps of Engineers' proposed mitigation plan: (1) did not adequately replace the wildlife resources lost with the project; (2) would allow critical forested wetlands habitats to be replaced with less valuable habitats; (3) would allow credits for management of lands associated with five other projects to offset TTW losses; (4) did not address unquantified, indirect impacts; (5) assigned a higher biological value for reservoir marsh and disposal areas than can be reasonably justified. *Referral letter from Deputy Assistant Secretary for Policy, Budget and Administration, Department of the Interior, to Chairman, CEQ*, December 28, 1984.

national importance: "National environmental resource issues include the destruction of approximately 34,000 acres of forested wetlands, a habitat recognized for its biological importance and critically diminished on a regional basis." *Referral letter, Department of the Interior.*

CEQ actions: Upon review of the documents submitted by the lead and referring agencies, the EIS for the proposed mitigation plan, and letters from the public, CEQ determined that there were significant unresolved questions regarding this proposal. To better understand the reasoning of both agencies, the Council held an open Sunshine Act meeting with representatives of both agencies on February 19, 1985, and asked the agencies to address specifically certain questions. As a result of the meeting and the materials reviewed in connection with the meeting, CEQ determined it was necessary to address two basic issues: (1) in-kind replacement of special resources, and (2) the use of land or other projects for mitigating habitat losses on the Tennessee-Tombigbee.

final CEQ action date: March 26, 1985.

result: CEQ published its findings and recommendations in the *Federal Register* on April 1, 1985. CEQ made the following recommendations regarding the two primary issues:

"The Council believes that the bottomland hardwoods in the Southeast are of such importance as wildlife habitats, and becoming so scarce, that the principle of full, in-kind replacement should override other considerations. We strongly recommend that the Department of the Interior and the Corps of Engineers work out a mitigation plan that fully replaces the 34,000 acres of bottomland hardwoods lost, through a combination of management and acquisition (public or private) of bottomland hardwood habitats.

"We recommend that the two agencies reach an agreement whereby the management of lands on the five existing projects can be used for credit on the Tennessee-Tombigbee consistent with the principle of in-kind replacement of bottomland hardwoods." 50 *Fed. Reg.* 12850 (1985).

References

1. 42 U.S.C. §§ 4321–4347 (1976).
2. 42 U.S.C. § 4331(a) (1976).
3. 42 U.S.C. § 4332(c) (1976).
4. 35 Fed. Reg. 7391 (1970).
5. 36 Fed. Reg. 7724 (1971).

6. 38 Fed. Reg. 20550 (1973), 40 C.F.R. § 1500 (1977).
7. 40 C.F.R. § 1500.3 (1984).
8. 40 C.F.R. § 1500.2(b) (1984).
9. 40 C.F.R. § 1507.3(a) (1984).
10. 40 C.F.R. § 1501.5(e) (1984).
11. 40 C.F.R. § 1504.1(a) (1984).
12. 49 Fed. Reg. 49750 (1984).
13. 695 F.2d 957 (5th Cir. 1983). For a discussion of this case, see Council on Environmental Quality, *Environmental Quality 1983* (1984), pp. 259–260.
14. 49 Fed. Reg. 50744 (1984).
15. *Clark v. Southern Oregon Citizens Against Toxic Sprays*, 720 F.2d 1475 (9th Cir. 1983), *cert. denied*, 53 U.S.L.W. 3366 (U.S. Nov. 3, 1984) (No. 84–267).
16. *Village of False Pass v. Watt*, 565 F. Supp. 1123 (D. Alaska 1983).
17. For a more detailed discussion of the district court decision, see Council on Environmental Quality, *Environmental Quality 1983* (1984), pp. 263–264.
18. 565 F. Supp. at 1152–53.
19. 40 C.F.R. § 1502.22(b)(1984).
20. 733 F.2d at 614.
21. *Id.*
22. *Id.* at 615.
23. *Id.* at 616–16.
24. *Id.* at 615.
25. *Id.* at 617–620.
26. 751 F.2d at 1299–1300.
27. *Id.* at 1300–1302.
28. *Id.* at 1303.
29. *Id.* at 1301.
30. *Id.* at 1303.
31. 40 C.F.R. § 1506.12(a).
32. 751 F.2d at 1304.
33. 582 F. Supp. 1489 (W.D. Wis. 1984).
34. 40 C.F.R. 1502.9(c) (1984).
35. 745 F.2d at 418.
36. *Id.* at 424.
37. 621 F.2d 1017 (9th Cir. 1980).
38. 745 F.2d at 430–431.
39. *Id.* at 428.
40. 33 U.S.C. § 1344 *et seq.* (1976).
41. 721 F.2d at 782.
42. *Id.* at 783.
43. 743 F.2d at 679.
44. *Id.* at 682.
45. *Flint Ridge Development Co. v. Scenic Rivers Association*, 426 U.S. 776, 792, 96 S.Ct. 2430, 2400, 49 L.Ed.2d 305 (1976).
46. 743 F.2d at 683–684.
47. *Id.* at 685.

48. *Id.*
49. 737 F.2d at 1091.
50. *Id.* at 1092.
51. *Id.* at 1091.
52. 592 F. Supp. at 943.
53. 587 F. Supp. at 764.
54. *Id.* at 769.
55. 40 C.F.R. § 1504 *et seq.* (1984).
56. 42 U.S.C. § 7609 (1970).
57. 40 C.F.R. § 1504.3(f) (1984).
58. Guidelines, Section 1500.9(b), 38 Fed. Reg. 20555 (1973).
59. 42 Fed. Reg. 61067, 61068 (1977).
60. 49 Fed. Reg. 37657 (1984).
61. The proposed Palmdale International Airport was referred to CEQ by the Department of Defense in August 1982. However, at the request of the Federal Aviation Administration (the lead agency), there has been an indefinite extension of the referral. Meanwhile, the FAA is taking no action to implement the project, unless the referral issues are resolved.
62. 49 Fed. Reg. 29812 (1984).
63. 49 Fed. Reg. 37657 (1984).

Appendix A

Report on the Activities of the Council on Environmental Quality During 1984

The Council on Environmental Quality (CEQ) was established within the Executive Office of the President by the National Environmental Policy Act of 1969 (NEPA) (See Appendix B) to formulate and recommend national policies to promote the improvement of the quality of the environment. The Council consists of three members appointed by the President with the advice and consent of the United States Senate. One of the members is designated by the President as Chairman. Since its inception, CEQ has been influential in shaping the nation's approach to protecting and preserving the environment.

Office of the Chairman

The Chairman of CEQ, A. Alan Hill, as a member of the White House Cabinet Council on Natural Resources and Environment, helps oversee and direct the Administration's environment and natural resource policies. That Cabinet Council has recently been incorporated into the Domestic Policy Council. In addition, Chairman Hill represents the President at formal national and international meetings concerned with environmental affairs. In these meetings, the Chairman acts in concert with heads of other agencies with responsibilities for environmental protection.

As the head of the agency, the Chairman assists in overseeing implementation of the President's environmental decisions. He is actively involved in both preparing and commenting on drafts of environmental messages, executive orders and decision memoranda. He directs the work of the Council and the Office of Environmental Quality, which provides staff support for the Council.

In order to enable the agency to provide practical and informed advice to the President, numerous discussions are held with representatives of science, industry, agriculture, labor, conservation organizations, state and local governments and other groups. For example, the CEQ Chairman had 71 meetings with various organizations in FY 1984. The resulting dialogue assists the Council in performing its responsibilities in a manner which is responsive to the public concerns.

The CEQ Chairman also serves as Chairman of the Global Issues Working Group (GIWG), which was established at the request of the President in September, 1981. The GIWG is composed of senior policy representatives from 18 major federal agencies. It serves to coordinate development of the Executive Branch's response to some of the most pressing global problems of environment, population and resources.

Council Members

The two Council Members are responsible for specific projects and studies,

in addition to representing CEQ on interagency committees and task forces and at international meetings.

William L. Mills, Ph.D., has primary responsibility for the Council's Management Fund. The Management Fund is used for interagency contracts and task forces. CEQ initiates or co-sponsors conferences, studies, surveys, analyses, publications and research pertaining to current environmental issues. This work, much of it performed under contract, is financed directly from the Management Fund to which funds are contributed by various agencies with environmental responsibilities. Dr. Mills is responsible for peer review of all contracts under the Fund, quality control, schedule monitoring, budget control and payment certification. He also serves as the Council's liaison between the Office of Administration in the Executive Office of the President and potential contractors.

Dr. Mills is the Council's representative on the sub-Cabinet level Working Group on Biotechnology, an interagency body which provides guidance on the adequacy of federal laws and regulations to protect public health and the environment from the possible hazards associated with the products and process of biotechnology. The efforts of this working group are described in Chapter 10, Issues in Environmental Science.

During 1984, the Council was directed by the Congress to "conduct a study to consider and define a National Center for Water Resources Research, and a study to define and plan a National Clearinghouse for Water Resources Information." (P.L. 98–191). Dr. Mills served as the Council's Study Director for this project and has continued to work closely with the National Association of State Water Resources Research Institute Directors and the Congress to further analyze and discuss the results of the water study.

Additionally during 1984, in response to a request from the U.S. Senate, Dr. Mills conducted an investigation of the Tijuana, Mexico/Imperial Beach, California sewage problem and advised the Senate of his findings in a formal report.

Council Member Jacqueline Schafer is in charge of the preparation of the President's annual Environmental Quality Report to the Congress. In this capacity, she is responsible for developing and approving all material to be included in the report, both from in-house sources and other federal agencies. This year's report is the fifteenth produced and contains information and analysis, as required by law, on the status and condition of the nation's environment, and the trends in the quality, management and utilization of its air, land and water; on the adequacy of natural resources to meet the requirements of a growing population; and on government and private programs and activities that affect the protection of the environment and the conservation and development of natural resources.

In addition, Member Schafer is responsible for overseeing the internal management of the programs and expenditures of the Interagency Task Force on Acid Precipitation (ITFAP). The Council on Environmental Quality was designated by the White House to serve as Executive Secretary to the Task Force. The goal of the National Acid Precipitation Assessment Program, established by Congress in late 1980, is to develop and improve on an objective and comprehensive scientific and technical information base for use by decisionmakers. The ITFAP sponsors studies, projects and conferences involving both the national and international community concerned with the problem of acid

precipitation. The acid deposition research program is described in Chapter 10 of this report.

Miss Schafer was also designated by the President to represent the United States on the official delegation to the International Conference on Population convened under United Nations auspices in August 1984 in Mexico City. The conference was called to review progress under the World Population Plan of Action adopted a decade ago by the World Population Conference held in Bucharest, Romania in 1974. Chapter 11 of this report, International Environmental Issues, includes a review of world population trends and the results of the conference.

As CEQ's policy representative on an interagency committee chaired by the Agency for International Development, Member Schafer has assisted in the preparation of a proposed United States strategy to protect and conserve biological diversity in developing countries. U.S. international wildlife conservation activities are discussed in Chapter 11.

Office of Environmental Quality

The Environmental Quality Improvement Act of 1970, P.L. 91–114 (see Appendix B) established the Office of Environmental Quality (OEQ) to provide staff and support for the Council. At the end of 1984, the professional and support staff of the Office consisted of seven full-time employees and one part-time employee. CEQ also relies upon professional and support staff temporarily detailed to the Executive Office of the President from other federal agencies. The number of detailees varies and numbered four at the end of the year. As of June 30, 1985, the OEQ Staff included the following individuals:

Julia Alessio	Paralegal Specialist
Dinah Bear	General Counsel
Bernice Carney	Administrative Officer
Susan Cohen	Executive Assistant to the Chairman
Carol Comer	Assistant to the Annual Report Editor
Donna Connell (part time)	Program Assistant
Christopher De Paola	Summer Intern
Harvey Doerksen, Ph.D. (detail)	Environmental Data & Monitoring/Water Resources Research
John Elliott (detail)	Global Isues Working Group/Annual Report
Lynne Grant	Confidential Assistant to the Members
Kemp Harshman	Deputy General Counsel/Executive Officer
Carla Mahdi (detail)	Secretary/Receptionist
Judith B. Morton	Environmental Policy Writer

NEPA Oversight

Throughout the year, the Council continued to fulfill its responsibilities with regard to the implementation and administration of the federal environmental assessment process. CEQ's activities in this area during 1984 are discussed in Chapter 12 of this Report.

Environmental Policy Development Studies and Projects

Early in 1984, the Council began work on the national water study requested by the Congress, which was completed within the limited time constraints established by Congress and at a cost of less than half the amount appropriated. The resulting report, *Alternatives for a National Water Resources Research Center and Information Clearinghouse,* prepared by the Chesapeake Research Consortium for CEQ (September 28, 1984) is available in limited quantities from the Council.

The Council's Long-Term Environmental Research Conference, which is described in Chapter 10 of this Report, was concluded in 1984. A report on the proceedings was published in March 1985: *Report on Long-Term Environmental Research and Development.*

Publications

During 1984, the Council published several significant reports:

- *Environmental Quality 1983.* The 14th Annual Report of the Council on Environmental Quality was presented to the President for transmittal to the Congress in a signing ceremony held on Theodore Roosevelt Island. The cover of this year's annual report depicts the statute of President Roosevelt dominating the 88.5-acre preserve located on an island in the Potomac River.
- *Corporate Use of Information Regarding Natural Resources and Environmental Quality.* (Russell E. Train, President, World Wildlife Fund) This report was the result of an in-depth study about private sector uses of resource information sources provided by the federal government. It was distributed to key federal policymakers, among others, to assist them in evaluating the relevance and usefulness of agency information services.
- *U.S. Government Participation in International Treaties, Agreements, Organizations and Programs.* This report was prepared by the Department of State in conjunction with the Global Issues Working Group and is an inventory of multilateral and bilateral agreements in the environment and natural resources area.

Council Members and Their Dates of Service

Name	Position	Date of Commission	Separation Date
Russell E. Train	Chairman	February 9, 1970	September 13, 1973
Robert Cahn	Member	February 9, 1970	September 5, 1972
Gordon J. MacDonald	Member	February 9, 1970	August 29, 1972
John A. Busterud	Member	October 10, 1972	
	Chairman	December 9, 1976	April 11, 1977
Beatrice Willard	Member	October 10, 1972	January 12, 1977
Russell W. Peterson	Chairman	November 26, 1973	October 1, 1976
Charles Hugh Warren	Chairman	March 8, 1977	June 30, 1979
James Gustave Speth	Member	April 4, 1977	
	Chairman	July 26, 1979	January 1, 1981
Jane Hunt Yarn	Member	August 31, 1978	January 20, 1981
Robert H. Harris	Member	November 19, 1979	January 20, 1981
A. Alan Hill	Chairman	July 14, 1981	
W. Ernst Minor	Member	July 14, 1981	June 25, 1983
Nancy A. Maloley	Member	July 26, 1982	January 21, 1984
William L. Mills	Member	November 11, 1983	
Jacqueline E. Schafer	Member	May 25, 1984	

Appendix B

Statutory Authorities of the Council on Environmental Quality and the Office of Environmental Quality

The National Environmental Policy Act, as Amended*

An Act to establish a national policy for the environment, to provide for establishment of a Council on Environmental Quality, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That this Act may be cited as the "National Environmental Policy Act of 1969".

Purpose

Sec. 2. The purposes of this Act are: To declare a national policy which will encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; to enrich the understanding of the ecological systems and natural resources important to the Nation; and to establish a Council on Environmental Quality.

Title I

Declaration of National Environmental Policy

Sec. 101. (a) The Congress, recognizing the profound impact of man's activity on the interrelations of all components of the natural environment, particularly the profound influences of population growth, high-density urbanization, industrial expansion, resource exploitation, and new and expanding technological advances and recognizing further the critical importance of restoring and maintaining environmental quality to the overall welfare and development of man, declares that it is the continuing policy of the Federal Government, in cooperation with State and local governments, and other concerned public and private organizations, to use all practicable means and measures, including financial and technical assistance, in a manner calculated to foster and promote the general welfare, to create and maintain conditions under which man and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Americans.

(b) In order to carry out the policy set forth in this Act, it is the continuing responsibility of the Federal Government to use all practicable means, consistent with other essential considerations of national policy, to improve and

*Pub.L. 91–190, 42 U.S.C. 4321–4347, January 1, 1970, as amended by Pub.L. 94–52, July 30, 1975, and Pub.L. 94–83, August 9, 1975.

coordinate Federal plans, functions, programs, and resources to the end that the Nation may—

(1) fulfill the responsibilities of each generation as trustee of the environment for succeeding generations;

(2) assure for all Americans safe, healthful, productive, and esthetically and culturally pleasing surroundings;

(3) attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences;

(4) preserve important historic, cultural, and natural aspects of our national heritage, and maintain, wherever possible, an environment which supports diversity and variety of individual choice;

(5) achieve a balance between population and resource use which will permit high standards of living and a wide sharing of life's amenities; and

(6) enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources.

(c) The Congress recognizes that each person should enjoy a healthful environment and that each person has a responsibility to contribute to the preservation and enhancement of the environment.

Sec. 102. The Congress authorizes and directs that, to the fullest extent possible: (1) the policies, regulations, and public laws of the United States shall be interpreted and administered in accordance with the policies set forth in this Act, and (2) all agencies of the Federal Government shall—

(A) utilize a systematic, interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts in planning and in decisionmaking which may have an impact on man's environment;

(B) identify and develop methods and procedures, in consultation with the Council on Environmental Quality established by title II of this Act, which will insure that presently unquantified environmental amenities and values may be given appropriate consideration in decisionmaking along with economic and technical considerations;

(C) include in every recommendation or report on proposals for legislation and other major federal actions significantly affecting the quality of the human environment, a detailed statement by the responsible official on—

(i) the environmental impact of the proposed action,

(ii) any adverse environmental effects which cannot be avoided should the proposal be implemented,

(iii) alternatives to the proposed action,

(iv) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and

(v) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

Prior to making any detailed statement, the responsible Federal official shall consult with and obtain the comments of any Federal agency which has jurisdiction by law or special expertise with respect to any environmental impact involved. Copies of such statement and the comments and views of the appropriate Federal, State, and local agencies, which are authorized to develop

and enforce environmental standards, shall be made available to the President, the Council on Environmental Quality and the public as provided by section 552 of title 5, United States Code, and shall accompany the proposal through the existing agency review processes;

(D) Any detailed statement required under subparagraph (C) after January 1, 1970, for any major Federal action funded under a program of grants to States shall not be deemed to be legally insufficient solely by reason of having been prepared by a State agency or official, if:

(i) the State agency or official has statewide jurisdiction and has the responsibility for such action,

(ii) the responsible Federal official furnishes guidance and participates in such preparation,

(iii) the responsible Federal official independently evaluates such statement prior to its approval and adoption, and

(iv) after January 1, 1976, the responsible Federal official provides early notification to, and solicits the views of, any other State or any Federal land management entity of any action or any alternative thereto which may have significant impacts upon such State or affected Federal land management entity and, if there is any disagreement on such impacts, prepares a written assessment of such impacts and views for incorporation into such detailed statement.

The procedures in this subparagraph shall not relieve the Federal official of his responsibilities for the scope, objectivity, and content of the entire statement or of any other responsibility under this Act; and further, this subparagraph does not affect the legal sufficiency of statements prepared by State agencies with less than statewide jurisdiction.

(E) study, develop, and describe appropriate alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources;

(F) recognize the worldwide and long-range character of environmental problems and, where consistent with the foreign policy of the United States, lend appropriate support to initiatives, resolutions, and programs designed to maximize international cooperation in anticipating and preventing a decline in the quality of mankind's world environment;

(G) make available to States, counties, municipalities, institutions, and individuals, advice and information useful in restoring, maintaining, and enhancing the quality of the environment;

(H) initiate and utilize ecological information in the planning and development of resource-oriented projects; and

(I) assist the Council on Environmental Quality established by title II of this Act.

Sec. 103. All agencies of the Federal Government shall review their present statutory authority, administrative regulations, and current policies and procedures for the purpose of determining whether there are any deficiencies or inconsistencies therein which prohibit full compliance with the purposes and provisions of this Act and shall propose to the President not later than July 1, 1971, such measures as may be necessary to bring their authority and policies into conformity with the intent, purposes, and procedures set forth in this Act.

Sec. 104. Nothing in Section 102 or 103 shall in any way affect the specific

statutory obligations of any Federal agency (1) to comply with criteria or standards of environmental quality, (2) to coordinate or consult with any other Federal or State agency, or (3) to act, or refrain from acting contingent upon the recommendations or certification of any other Federal or state agency.

Sec. 105. The policies and goals set forth in this Act are supplementary to those set forth in existing authorizations of Federal agencies.

Title II

Council on Environmental Quality

Sec. 201. The President shall transmit to the Congress annually beginning July 1, 1970, an Environmental Quality Report (hereinafter referred to as the "report") which shall set forth (1) the status and condition of the major natural, manmade, or altered environmental classes of the Nation, including, but not limited to, the air, the aquatic, including marine, estuarine, and fresh water, and the terrestrial environment, including, but not limited to, the forest, dryland, wetland, range, urban, suburban, and rural environment; (2) current and foreseeable trends in the quality, management and utilization of such environments and the effects of those trends on the social, economic, and other requirements of the Nation; (3) the adequacy of available natural resources for fulfilling human and economic requirements of the Nation in the light of expected population pressures; (4) a review of the programs and activities (including regulatory activities) of the Federal Government, the State and local governments, and nongovernmental entities or individuals, with particular reference to their effect on the environment and on the conservation, development and utilization of natural resources; and (5) a program for remedying the deficiencies of existing programs and activities, together with recommendations for legislation.

Sec. 202. There is created in the Executive Office of the President a Council on Environmental Quality (hereinafter referred to as the "Council"). The Council shall be composed of three members who shall be appointed by the President to serve at his pleasure, by and with the advice and consent of the Senate. The President shall designate one of the members of the Council to serve as Chairman. Each member shall be a person who, as a result of his training, experience, and attainments, is exceptionally well qualified to analyze and interpret environmental trends and information of all kinds; to appraise programs and activities of the Federal Government in the light of the policy set forth in title I of this Act; to be conscious of and responsive to the scientific, economic, social, esthetic, and cultural needs and interests of the Nation; and to formulate and recommend national policies to promote the improvement of the quality of the environment.

Sec. 203. The Council (a) may employ such officers and employees as may be necessary to carry out its functions under this Act. In addition, the Council may employ and fix the compensation of such experts and consultants as may be necessary for the carrying out of its functions under this Act, in accordance with section 3109 of title 5, United States Code (but without regard to the last sentence thereof).

(b) Notwithstanding section 3679(b) of the Revised Statutes (31 U.S.C.

665(b)), the Council may accept and employ voluntary and uncompensated services in furtherance of the purposes of the Council.

Sec. 204. It shall be the duty and function of the Council—

(1) to assist and advise the President in the preparation of the Environmental Quality Report required by section 201;

(2) to gather timely and authoritative information concerning the conditions and trends in the quality of the environment both current and prospective, to analyze and interpret such information for the purpose of determining whether such conditions and trends are interfering, or are likely to interfere, with the achievement of the policy set forth in title I of this Act, and to compile and submit to the President studies relating to such conditions and trends;

(3) to review and appraise the various programs and activities of the Federal government in the light of the policy set forth in title I of this Act for the purpose of determining the extent to which such programs and activities are contributing to the achievement of such policy, and to make recommendations to the President with respect thereto;

(4) to develop and recommend to the President national policies to foster and promote the improvement of environmental quality to meet the conservation, social, economic, health, and other requirements and goals of the Nation;

(5) to conduct investigations, studies, surveys, research, and analyses relating to ecological systems and environmental quality;

(6) to document and define changes in the natural environment, including the plant and animal systems, and to accumulate necessary data and other information for a continuing analysis of these changes or trends and an interpretation of their underlying causes;

(7) to report at least once each year to the President on the state and condition of the environment; and

(8) to make and furnish such studies, reports thereon, and recommendations with respect to matters of policy and legislation as the President may request.

Sec. 205. In exercising its powers, functions, and duties under this Act, the Council shall—

(1) consult with the Citizens' Advisory Committee on Environmental Quality established by Executive Order numbered 11471, dated May 29, 1969, and with such representatives of science, industry, agriculture, labor, conservation organizations, State and local governments and other groups, as it deems advisable; and

(2) utilize, to the fullest extent possible, the services, facilities, and information (including statistical information) of public and private agencies and organizations, and individuals, in order that duplication of effort and expense may be avoided, thus assuring that the Council's activities will not unnecessarily overlap or conflict with similar activities authorized by law and performed by established agencies.

Sec. 206. Members of the Council shall serve full time and the Chairman of the Council shall be compensated at the rate provided for Level II of the Executive Schedule Pay Rates (5 U.S.C. 5313). The other members of the Council shall be compensated at the rate provided for Level IV of the Executive Schedule Pay Rates (5 U.S.C. 5315).

Acceptance of Travel Reimbursement

Sec. 207. The Council may accept reimbursements from any private nonprofit organization or from any department, agency, or instrumentality of the Federal Government, any State, or local government, for the reasonable travel expenses incurred by an officer or employee of the Council in connection with his attendance of any conference, seminar, or similar meeting conducted for the benefit of the Council.

Expenditures for International Travel

Sec. 208. The Council may make expenditures in support of its international activities, including expenditures for: (1) international travel; (2) activities in implementation of international agreements; and (3) the support of international exchange programs in the United States and in foreign countries.

Sec. 209. There are authorized to be appropriated to carry out the provisions of this Act not to exceed $300,000 for fiscal year 1970, $700,000 for fiscal year 1971, and $1,000,000 for each fiscal year thereafter.

Approved January 1, 1970.

The Environmental Quality Improvement Act of 1970*

Title II—Environmental Quality
(of the Water Quality Improvement Act of 1970)

Short Title

Sec. 201. This title may be cited as the "Environmental Quality Improvement Act of 1970."

Findings, Declarations, and Purposes

Sec. 202. (a) The Congress finds—

(1) that man has caused changes in the environment;

(2) that many of these changes may affect the relationship between man and his environment; and

(3) that population increases and urban concentration contribute directly to pollution and the degradation of our environment.

(b)(1) The Congress declares that there is a national policy for the environment which provides for the enhancement of environmental quality. This policy is evidenced by statutes heretofore enacted relating to the prevention, abatement, and control of environmental pollution, water and land resources, transportation, and economic and regional development.

(2) The primary responsibility for implementing this policy rests with State and local governments.

*Pub. L. 91–224, 42 U.S.C. 4371–4374, April 3, 1970, as amended by Pub. L. 95–300, June 26, 1978, Pub. L. 97–350, October 18, 1982, and Pub. L. 98–581, October 30, 1984.

(3) The Federal Government encourages and supports implementation of this policy through appropriate regional organizations established under existing law.

(c) The purposes of this title are—

(1) to assure that each Federal department and agency conducting or supporting public works activities which affect the environment shall implement the policies established under existing law; and

(2) to authorize an Office of Environmental Quality, which, notwithstanding any other provision of law, shall provide the professional and administrative staff for the Council on Environmental Quality established by Public Law 91–190.

Office of Environmental Quality

Sec. 203. (a) There is established in the Executive Office of the President an office to be known as the Office of Environmental Quality (hereafter in this title referred to as the "Office"). The Chairman of the Council on Environmental Quality established by Public Law 91–190 shall be the Director of the Office. There shall be in the Office a Deputy Director who shall be appointed by the President, by and with the advice and consent of the Senate.

(b) The compensation of the Deputy Director shall be fixed by the President at a rate not in excess of the annual rate of compensation payable to the Deputy Director of the Bureau of the Budget.

(c) The Director is authorized to employ such officers and employees (including experts and consultants) as may be necessary to enable the Office to carry out its functions under this title and Public Law 91–190, except that he may employ no more than ten specialists and other experts without regard to the provisions of title 5, United States Code, governing appointments in the competitive service, and pay such specialists and experts without regard to the provisions of chapter 51 and subchapter III of chapter 53 of such title relating to classification and General Schedule pay rates, but no such specialist or expert shall be paid at a rate in excess of the maximum rate for GS–18 of the General Schedule under section 5332 of title 5.

(d) In carrying out his functions the Director shall assist and advise the President on policies and programs of the Federal Government affecting environmental quality by—

(1) providing the professional and administrative staff and support for the Council on Environmental Quality established by Public Law 91–190;

(2) assisting the Federal agencies and departments in appraising the effectiveness of existing and proposed facilities, programs, policies, and activities of the Federal Government, and those specific major projects designated by the President which do not require individual project authorization by Congress, which affect environmental quality;

(3) reviewing the adequacy of existing systems for monitoring and predicting environmental changes in order to achieve effective coverage and efficient use of research facilities and other resources;

(4) promoting the advancement of scientific knowledge of the effects of actions and technology on the environment and encourage the development of the means to prevent or reduce adverse effects that endanger the health and well-being of man;

(5) assisting in coordinating among the Federal departments and agencies those programs and activities which affect, protect, and improve environmental quality;

(6) assisting the Federal departments and agencies in the development and interrelationship of environmental quality criteria and standards established through the Federal Government;

(7) collecting, collating, analyzing, and interpreting data and information on environmental quality, ecological research, and evaluation.

(e) The Director is authorized to contract with public or private agencies, institutions, and organizations and with individuals without regard to sections 3648 and 3709 of the Revised Statutes (31 U.S.C. 529; 41 U.S.C. 5) in carrying out his functions.

Report

Sec. 204. Each Environmental Quality Report required by Public Law 91–190 shall, upon transmittal to Congress, be referred to each standing committee having jurisdiction over any part of the subject matter of the Report.

Authorization

Sec. 205. There are hereby authorized to be appropriated for the operations of the Office of Environmental Quality and the Council on Environmental Quality not to exceed the following sums for the following fiscal years which sums are in addition to those contained in Public Law 91–190:

(a) $2,126,000 for the fiscal year ending September 30, 1979.

(b) $3,000,000 for each of the fiscal years ending September 30, 1980, and September 30, 1981.

(c) $44,000 for fiscal years ending September 30, 1982, 1983, and 1984.

(d) $480,000 for each of the fiscal years ending September 30, 1985 and September 30, 1986.

Office Management Fund

Sec. 206. (a) There is established an Office of Environmental Quality Management Fund (hereinafter referred to as the "Fund") to receive advance payments from other agencies or accounts that may be used solely to finance—

(1) study contracts that are jointly sponsored by the Office and one or more other Federal agencies; and

(2) Federal interagency environmental projects (including task forces) in which the Office participates.

(b) Any study contract or project that is to be financed under subsection (a) may be initiated only with the approval of the Director.

(c) The Director shall promulgate regulations setting forth policies and procedures for operation of the Fund.

Approved April 3, 1970.

Executive Order 11514, as Amended by Executive Order 11991, Secs. 2(g) and 3(h)), May 24, 1977,

Protection and Enhancement of Environmental Quality*

By virtue of the authority vested in me as President of the United States and in furtherance of the purpose and policy of the National Environmental Policy Act of 1969 (Public Law No. 91–190, approved January 1, 1970), it is ordered as follows:

Section 1. *Policy.* The Federal Government shall provide leadership in protecting and enhancing the quality of the Nation's environment to sustain and enrich human life. Federal agencies shall initiate measures needed to direct their policies, plans and programs so as to meet national environmental goals. The Council on Environmental Quality, through the Chairman, shall advise and assist the President in leading this national effort.

Sec. 2. *Responsibilities of Federal agencies.* Consonant with Title I of the National Environmental Policy Act of 1969, hereafter referred to as the "Act", the heads of Federal agencies shall:

(a) Monitor, evaluate, and control on a continuing basis their agencies' activities so as to protect and enhance the quality of the environment. Such activities shall include those directed to controlling pollution and enhancing the environment and those designed to accomplish other program objectives which may affect the quality of the environment. Agencies shall develop programs and measures to protect and enhance environmental quality and shall assess progress in meeting the specific objectives of such activities. Heads of agencies shall consult with appropriate Federal, State and local agencies in carrying out their activities as they affect the quality of the environment.

(b) Develop procedures to ensure the fullest practicable provision of timely public information and understanding of Federal plans and programs with environmental impact in order to obtain the views of interested parties. These procedures shall include, whenever appropriate, provision for public hearings, and shall provide the public with relevant information, including information on alternative courses of action. Federal agencies shall also encourage State and local agencies to adopt similar procedures for informing the public concerning their activities affecting the quality of the environment.

(c) Insure that information regarding existing or potential environmental problems and control methods developed as part of research, development, demonstration, test, or evaluation activities is made available to Federal agencies, States, counties, municipalities, institutions, and other entities, as appropriate.

(d) Review their agencies' statutory authority, administrative regulations, policies, and procedures, including those relating to loans, grants, contracts, leases, licenses, or permits, in order to identify any deficiencies or inconsistencies therein which prohibit or limit full compliance with the purposes and provisions of the Act. A report on this review and the corrective actions taken or planned, including such measures to be proposed to the President as may be necessary to bring their authority and policies into conformance with the intent, purposes, and procedures of the Act, shall be provided to the Council on Environmental Quality not later than September 1, 1970.

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*42 U.S.C. 4321 nt.

(e) Engage in exchange of data and research results, and cooperate with agencies of other governments to foster the purposes of the Act.

(f) Proceed, in coordination with other agencies, with actions required by section 102 of the Act.

(g) In carrying out their responsibilities under the Act and this Order, comply with the regulations issued by the Council except where such compliance would be inconsistent with statutory requirements.

Sec. 3. *Responsibilities of Council on Environmental Quality.* The Council on Environmental Quality shall:

(a) Evaluate existing and proposed policies and activities of the Federal Government directed to the control of pollution and the enhancement of the environment and to the accomplishment of other objectives which affect the quality of the environment. This shall include continuing review of procedures employed in the development and enforcement of Federal standards affecting environmental quality. Based upon such evaluations the Council shall, where appropriate, recommend to the President policies and programs to achieve more effective protection and enhancement of environmental quality and shall, where appropriate, seek resolution of significant environmental issues.

(b) Recommend to the President and to the agencies priorities among programs designed for the control of pollution and for enhancement of the environment.

(c) Determine the need for new policies and programs for dealing with environmental problems not being adequately addressed.

(d) Conduct, as it determines to be appropriate, public hearings or conferences on issues of environmental significance.

(e) Promote the development and use of indices and monitoring systems (1) to assess environmental conditions and trends, (2) to predict the environmental impact of proposed public and private actions, and (3) to determine the effectiveness of programs for protecting and enhancing environmental quality.

(f) Coordinate Federal programs related to environmental quality.

(g) Advise and assist the President and the agencies in achieving international cooperation for dealing with environmental problems, under the foreign policy guidance of the Secretary of State.

(h) Issue regulations to Federal agencies for the implementation of the procedural provisions of the Act (42 U.S.C. 4332(2)). Such regulations shall be developed after consultation with affected agencies and after such public hearings as may be appropriate. They will be designed to make the environmental impact statement process more useful to decisionmakers and the public; and to reduce paperwork and the accumulation of extraneous background data, in order to emphasize the need to focus on real environmental issues and alternatives. They will require impact statements to be concise, clear, and to the point, and supported by evidence that agencies have made the necessary environmental analyses. The Council shall include in its regulations procedures (1) for the early preparation of environmental impact statements, and (2) for the referral to the Council of conflicts between agencies concerning the implementation of the National Environmental Policy Act of 1969, as amended, and Section 309 of the Clean Air Act, as amended, for the Council's recommendation as to their prompt resolution.

(i) Issue such other instructions to agencies, and request such reports and

other information from them, as may be required to carry out the Council's responsibilities under the Act.

(j) Assist the President in preparing the annual Environmental Quality Report provided for in section 201 of the Act.

(k) Foster investigations, studies, surveys, research, and analyses relating to (i) ecological systems and environmental quality, (ii) the impact of new and changing technologies thereon, and (iii) means of preventing or reducing adverse effects from such technologies.

Sec. 4. *Amendments of E.O. 11472.* Executive Order No. 11472 of May 29, 1969, including the heading thereof, is hereby amended:

(1) By substituting for the term "the Environmental Quality Council", wherever it occurs, the following: "the Cabinet Committee on the Environment".

(2) By substituting for the term "the Council", wherever it occurs, the following: "the Cabinet Committee".

(3) By inserting in subsection (f) of section 101, after "Budget," the following: "the Director of the Office of Science and Technology,".

(4) By substituting for subsection (g) of section 101 the following:

"(g) The Chairman of the Council on Environmental Quality (established by Public Law 91–190) shall assist the President in directing the affairs of the Cabinet Committee."

(5) By deleting subsection (c) of section 102.

(6) By substituting for "the Office of Science and Technology", in section 104, the following: "the Council on Environmental Quality (established by Public Law 91–190)".

(7) By substituting for "(hereinafter referred to as the 'Committee')", in section 201, the following: "(hereinafter referred to as the 'Citizens' Committee')".

(8) By substituting for the term "the Committee", wherever it occurs, the following: "the Citizens' Committee".

March 3, 1970.

Appendix C

Statistical Appendix

In addition to the narrative description of environmental conditions and trends, it became the practice of the Council on Environmental Quality to include a series of statistical tables. These tables are used to provide a statistical record of changes over time in a broad spectrum of environmental variables.

The data used in this report are the product of a series of iterations of data selection and data culling that has taken place over the past 15 years. After an intensive search for environmental indices and indicators during its first five years, the Council on Environmental Quality published in 1975 the *National Environmental Statistical Report*. Prepared by the MITRE Corporation, this report contained a variety of environmental and related data presented in approximately 200 statistical and summary tables. In preparing the report, MITRE searched a large number of data sources for tables relevant to the various areas of environmental quality, and refined the list on the basis of numerous interviews with professionals in the field.

Three years later, the Council published *Environmental Statistics, 1978*, prepared by the Center for Environmental Reporting. The approximately 200 tables were selected on the basis of their ability to reveal trends or interesting conditions important to understanding the nature and quality of the environment. In the absence of fixed rules for determining what should be included (i.e., answering the questions: What is important and to whom? How well does a data series measure a given issue? Is the series meaningful, useful, and accurate?) the Center for Environmental Reporting sought broad reviews of the proposed list from agency personnel and acknowledged experts in the field.

By the time that *Environmental Trends* was published by the Council in 1981, the goal was to include data series that measured environmental changes associated with economic welfare, human health, recreational opportunity, aesthetic appreciation, and concern for ecological diversity and stability. Five criteria were used to help judge the usefulness and adequacy of the statistics:

1. Relevancy — that a statistical series provides data, wherever possible through direct measure, on a major environmental concern.
2. Selectivity — that as few statistical series as possible be used to measure an environmental issue.
3. Availability — that the statistical series be taken from data available in government agencies, private studies, or the literature of a given discipline.
4. Statistical quality — that the data be checked by experts to ensure that they are reasonably valid measures of environmental conditions.
5. Scope of Coverage — that national data be used whenever possible, with breakdowns shown only when especially meaningful.

The data series contained in this report owe their origin to these earlier searches for information on conditions and trends in the environment, particularly the 1981 *Environmental Trends* report. The information contained in the tables has been updated on a regular basis during the intervening years.

The tables contain the most recent data available as of mid-1985. Some tables that appeared in the 1983 Annual Report have been deleted because they contained data from one-time studies that will not be repeated, or because the most recent data are so out-of-data as to have little meaning for current environmental quality assessment.

While these tables present the best available data relevant to environmental policy, they should be viewed within the profession as an interim record in the evolving arena of environmental quality assessment.

In its early years, the Council on Environmental Quality achieved an unquestionable success in leading the development of the Pollutant Standards Index (PSI) for measuring air quality. This index, now in universal use by local governments and states throughout the Nation, is reported both in this statistical section and in the chapter on air quality. But this success has yet to be replicated for other areas of the environment.

In the future, it is expected that this series of tables will report the results of a variety of indicators of the type represented by the Pollutant Standards Index, that measure the quality of other environmental components, such as water, land, soil, forests, wildlife and coastal areas. These future indicators, like the PSI, will be: supported by a body of theory; monitored regularly on a national basis; displayed in such a way that the relative impact (positive and negative) of changes on environmental health is clearly evident; and easily understandable by the lay reader.

STATISTICAL TABLES

Pollution Control and Environmental Protection

Air Quality

Water Quality

Hazardous Chemicals

Energy

International

NEPA

National Ambient Air Pollutant Concentrations, 1975–1983[1]

Pollutant	Measurement units[2]	No. of sites[3]	1975	1976	1977	1978	1979	1980	1981	1982	1983
Total suspended particulate: Annual geometric mean[4]	ug/m³	1,510	60.8	61.7	61.2	60.4	61.1	62.6	58.4	49.5	48.7
Sulfur dioxide: Annual arithmetic mean	ppm	286	0.015	0.015	0.014	0.013	0.012	0.011	0.011	0.010	0.010
Carbon monoxide: Annual 2nd maximum nonoverlapping 8-hour average	ppm	174	11.89	11.22	10.61	10.00	9.57	8.87	8.78	8.00	7.91
Nitrogen dioxide: Annual arithmetic mean	ppm	177	0.027	0.027	0.028	0.030	0.030	0.029	0.027	0.026	0.026
Ozone: Annual 2nd daily maximum 1-hour average	ppm	176	0.154	0.154	0.153	0.153	0.139	0.142	0.128	0.126	0.141
Lead: Annual maximum quarterly averages[5]	ug/m³	61	1.00	0.97	1.02	0.91	0.69	0.49	0.43	0.40	0.33
		138	—	—	—	—	—	0.53	0.43	0.46	0.35

[1] The air quality statistics used in this report relate directly to the appropriate National Ambient Air Quality Standards.
[2] ug/m³ = micrograms per cubic meter; ppm = parts per million.
[3] For a monitoring site to be included in this analysis, the site had to contain at least 7 out of the 9 years of data in the period 1975 to 1983 and each of these years had to satisfy annual data completeness criteria.
[4] The trend in TSP is complicated by the fact that the glass fiber filters used to collect TSP data have been manufactured by different vendors. The filters used in 1979, 1980, and 1981 were found to record higher values than the filters used in 1978 and 1982, because of higher filter alkalinity, which is related to artifact error. The alkalinity of the 1978 and 1982 filters were found to be similar, so that TSP data for these years should be comparable.
[5] In order to increase the number of lead sites available for trend analysis, both an 8-year and 4-year time period are presented.

Source: U.S. Environmental Protection Agency, Office of Air and Radiation, *National Air Quality and Emission Trends Report, 1983* (Research Triangle Park, N.C.: April, 1985).

National Air Pollutant Emissions Estimates, by Pollutant and Source, 1983
(million metric tons per year)

Table A-2
Air Quality

	Transportation	Stationary Source Fuel Combustion	Industrial Processes	Solid Waste Disposal	Miscellaneous	Total
Particulates						
1940	2.7	7.1	8.4	0.5	3.7	22.4
1950	2.1	6.7	12.3	0.6	2.5	24.2
1960	0.7	5.5	12.0	0.9	1.8	20.9
1970	1.2	4.5	10.1	1.1	1.1	18.0
1980	1.4	2.2	3.2	0.4	1.1	8.3
1983	1.3	2.0	2.3	0.4	0.9	6.9
Sulfur Oxides						
1940	2.9	11.0	3.6	0.0	0.5	18.0
1950	2.3	12.9	4.6	0.0	0.5	20.3
1960	0.4	14.0	5.1	0.0	0.5	20.0
1970	0.6	21.3	6.2	0.0	0.1	28.2
1980	0.9	18.8	3.5	0.0	0.0	23.2
1983	0.9	16.8	3.1	0.0	0.0	20.8
Nitrogen Oxides						
1940	2.2	3.3	0.2	0.1	0.9	6.7
1950	3.5	4.7	0.3	0.2	0.6	9.3
1960	4.9	6.7	0.5	0.3	0.4	12.8
1970	7.6	9.1	0.7	0.4	0.3	18.1
1980	9.2	10.1	0.7	0.1	0.2	20.3
1983	8.8	9.7	0.6	0.1	0.2	19.4

National Air Pollutant Emissions Estimates, by Pollutant and Source, 1983—Continued
(million metric tons per year)

	Transportation	Stationary Source Fuel Combustion	Industrial Processes	Solid Waste Disposal	Miscellaneous	Total
Volatile Organic Compounds						
1940	5.2	3.9	3.2	0.9	4.5	17.7
1950	7.9	2.6	5.2	1.0	3.6	20.3
1960	11.1	1.6	6.1	1.4	3.1	23.3
1970	12.3	0.9	8.7	1.8	3.3	27.0
1980	8.2	1.7	8.9	0.6	2.9	22.3
1983	7.2	2.1	7.5	0.6	2.5	19.9
Carbon Monoxide						
1940	29.3	13.7	6.6	3.3	26.5	79.4
1950	43.6	9.9	10.5	4.3	16.5	84.8
1960	57.0	6.1	9.3	5.1	10.0	87.5
1970	71.8	3.9	9.0	6.4	7.2	98.3
1980	52.7	6.2	6.3	2.2	7.6	75.0
1983	47.7	7.0	4.6	2.0	6.3	67.6

Source: U.S. Environmental Protection Agency, *National Air Pollutant Emission Estimates, 1940-1983* (Research Triangle Park, N.C.: December 1984).

National Air Pollutant Emissions Estimates, by Pollutant, 1940-1983
(million metric tons per year)

Year	Partic-ulates	Percent of 1974	Sulfur oxides	Percent of 1974	Nitrogen oxides	Percent of 1974	Volatile organic compounds	Percent of 1974	Carbon monoxide	Percent of 1974
1940	22.4	184	18.0	67	6.7	34	17.7	73	79.4	94
1950	24.2	198	20.3	75	9.3	47	20.3	84	84.8	100
1960	20.9	171	20.0	74	12.8	65	23.3	97	87.5	103
1970	18.0	148	28.2	104	18.1	92	27.0	112	98.3	116
1971	16.7	137	26.8	99	18.5	94	26.3	109	96.3	114
1972	15.0	123	27.4	101	19.7	101	26.3	109	93.8	111
1973	13.9	114	28.7	106	20.2	103	25.7	107	89.5	106
1974	12.2	100	27.0	100	19.6	100	24.1	100	84.6	100
1975	10.3	84	25.6	95	19.1	97	22.7	94	80.5	95
1976	9.6	79	26.2	97	20.3	104	23.8	99	85.3	101
1977	9.0	74	26.3	97	20.9	107	23.6	98	81.1	96
1978	8.9	73	24.5	91	21.0	107	24.2	100	80.6	95
1979	8.8	72	24.5	91	21.1	108	23.5	98	77.4	91
1980	8.3	68	23.2	86	20.3	104	22.3	93	75.0	89
1981	7.7	63	22.3	83	20.5	105	21.0	87	72.3	87
1982	6.8	56	21.3	79	19.6	100	19.4	80	66.1	78
1983	6.9	57	20.8	77	19.4	99	19.9	83	67.6	80
Changes 1970–1983	–62%		–26%		+7%		–26%		–31%	

Source: U.S. Environmental Protection Agency, *National Air Pollutant Emission Estimates, 1940-1983* (Research Triangle Park, N.C.: December 1984).

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Fuel Economy and Standards for Autos, 1940–1985
(miles per gallon)

Year	Fuel Economy: All cars[1]	Fuel Economy: New cars[2]	Fuel Economy: Standards[3]	Year	Fuel economy: All cars[1]	Fuel economy: New cars[2]	Fuel economy: Standards[3]	Year	Fuel economy: All cars[1]	Fuel economy: New cars[2]	Fuel economy: Standards[3]
1940	15.29	...	...	1961	14.38	...	...	1974	13.43	14.2	
1945	15.03	...	...	1962	14.37	...	...	1975	13.53	15.8	
1950	14.95	...	...	1963	14.26	...	...	1976	13.72	17.5	
1951	14.99	...	...	1964	14.25	...	...	1977	13.94	18.3	
1952	14.67	...	...	1965	14.07	...	...	1978	14.06	19.9	18.0
1953	14.70	...	...	1966	14.00	...	...	1979	14.29	20.1	19.0
1954	14.58	...	...	1967	13.93	14.9	...	1980	15.15	22.4	20.0
1955	14.53	...	...	1968	13.79	14.7	...	1981	15.54	25.2	22.0
1956	14.36	...	...	1969	13.63	14.7	...	1982	16.25	26.1	24.0
1957	14.40	...	...	1970	13.57	14.9	...	1983	16.70	26.0[4]	26.0
1958	14.30	...	...	1971	13.57	14.4	...	1984	...	26.6[4]	27.0
1959	14.30	...	...	1972	13.49	14.5	...	1985	...	27.2[4]	27.5
1960	14.28	...	...	1973	13.10	14.2	...				

Data are not strictly comparable.
[1]Data for all cars are based on the average number of miles traveled per gallon of fuel consumed.
[2]Data for new cars are based on the 1975 Federal Test Procedure, which is weighted to take into account both city and highway driving. New cars, 1967–1974 model years, production data were used; 1975–1980 model years, manufacturers' sales forecast data were used.
[3]Federal fuel economy standards.
[4]Estimated.

Sources:
All cars: U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics 1983* (Washington, D.C. 1984), and previous annual issues;
New cars: Environmental Protection Agency, Office of Mobile Sources (May 1985).

Exhaust Emission Standards for Autos and Light Trucks, 1968–1985

Year	Standards for new autos (grams per miles)			Percent reduction of standards from pre-control vehicles		
	Hydro-carbons	Carbon monoxide	Nitrogen oxides	Hydro-carbons	Carbon monoxide	Nitrogen oxides
1968	4.1	34.0	NA	50	62	NA
1969	4.1	34.0	NA	50	62	NA
1970	4.1	34.0	NA	50	62	NA
1971	4.1	34.0	NA	50	62	NA
1972	3.0	28.0	3.1	63	69	9
1973	3.0	28.0	3.1	63	69	9
1974	3.0	28.0	3.1	63	69	9
1975	1.5	15.0	3.1	82	83	9
1976	1.5	15.0	3.1	82	83	9
1977	1.5	15.0	2.0	82	83	41
1978	1.5	15.0	2.0	82	83	41
1979	1.5	15.0	2.0	82	83	41
1980	0.41	7.0	2.0	96	92	41
1981	0.41	3.4	1.0	96	96	76
1982	0.41	3.4	1.0	96	96	76
1983	0.41	3.4	1.0	96	96	76
1984	0.41	3.4	1.0	96	96	76
1985	0.41	3.4	1.0	96	96	76

Exhaust Emission Standards for Autos and Light Trucks, 1968-1985—Continued

Table A-5
Air quality

Year	Standards for new light trucks (grams per miles) Hydro-carbons	Carbon monoxide	Nitrogen oxides	Percent reduction of standards from pre-control vehicles Hydro-carbons	Carbon monoxide	Nitrogen oxides
1968	4.1	34.0	NA	50	62	NA
1969	4.1	34.0	NA	50	62	NA
1970	4.1	34.0	NA	50	62	NA
1971	4.1	34.0	NA	50	62	NA
1972	3.0	28.0	3.1	63	69	9
1973	3.0	28.0	3.1	63	69	9
1974	3.0	28.0	3.1	63	69	9
1975	2.0	20.0	3.1	76	78	9
1976	2.0	20.0	3.1	76	78	9
1977	2.0	20.0	3.1	76	78	9
1978	2.0	20.0	3.1	76	78	9
1979	1.7	18.0	2.3	79	80	32
1980	1.7	18.0	2.3	79	80	32
1981	1.7	18.0	2.3	79	80	32
1982	1.7	18.0	2.3	79	80	32
1983	1.7	18.0	2.3	79	80	32
1984	0.8	10.0	2.3	90	89	32
1985	0.8	10.0	0.9	90	89	74

NA - Not applicable.
All standards are based on current test procedure. Standards for hydrocarbons and carbon monoxide were not established until 1968, for nitrogen dioxides, not until 1972.

Source: National Commission on Air Quality, *To Breathe Clean Air* (Washington, D.C.: 1981), p. 194.

Oil and Hazardous Spills in U.S. Water, 1971–1983 and By Location, 1983

Table A-6
Water quality

Year	Total		Oil		Hazardous		Other	
	Number of incidents	Millions gallons	Number of incidents	Millions gallons	Number of incidents	Millions gallons	Number of incidents	Millions gallons
1971	8,736	8.8	7,522	8.6	NA	NA	1,214	0.2
1972	9,931	18.8	8,380	16.8	NA	NA	1,551	2.0
1973	13,232	22.1	10,995	15.4	237	.4	2,000	6.3
1974	14,432	19.4	11,902	16.7	220	1.0	2,310	1.8
1975	12,781	22.2	10,868	21.7	239	.5	1,674	.1
1976	13,930	36.6	11,700	24.4	299	2.1	1,931	10.1
1977	15,330	12.2	12,605	10.0	289	1.4	2,436	.8
1978	14,495	17.6	11,950	14.3	261	2.2	2,284	1.1
1979	13,134	13.7	10,990	10.5	239	.4	1,905	2.7
1980	9,782	15.1	7,837	10.2	133	4.6	1,812	.3
1981	10,564	19.8	8,820	17.8	93	1.1	1,651	.9
1982	10,175	13.4	8,612	9.2	266	.5	1,297	3.7
1983[1]	10,969	21.2	9,208	8.3	301	1.8	1,460	11.2

Oil and Hazardous Spills in U.S. Water, 1971-1982 and By Location, 1983—Continued

Year	Total		Oil		Hazardous		Other	
	Number of incidents	Millions gallons	Number of incidents	Millions gallons	Number of incidents	Millions gallons	Number of incidents	Millions gallons
1983 by location[1]								
Inland	4,447	8.4	3,639	6.0	235	1.3	573	1.1
Atlantic	2,375	1.0	1,921	.5	20	.5	434	.0
Pacific	1,416	11.3	1,205	1.2	8	.0	203	10.0
Gulf	2,646	.6	2,364	.6	38	.0	244	.0
Great Lakes	23	.0	21	.0	0	.0	2	.0
Other	62	.0	58	.0	0	.0	4	.0

Areas affected include the Great Lakes, ocean waters within 200 miles of the coast, and inland waters (rivers, channels, harbors, etc.). Sources of spills include vessels, land vehicles, nontransportation-related facilities, pipelines, marine facilities, and land facilities.

Data are compiled from the U.S. Coast Guard's Pollution Incident Reporting System (PIRS).

[1]Preliminary data.

Sources:
1983: U.S. Department of Transportation, Coast Guard, *Polluting Incidents In and Around U.S. Waters, Calendar Year 1982 and 1983* (Washington, D.C.: 1984), and earlier reports.

Population Served by Municipal Wastewater Systems, by Level of Treatment, 1960–1984 — Table A-7
(million people) — Water quality

Service and degree	1960	1970	1978	1980	1982	1983	1984
Total U.S. population	180	203	220	224	230	230	230
Not served by wastewater systems	70	58	66	65	62	61	61
Total served by wastewater systems	110	145	154	159	168	169	169
Served, but no treatment	70	59	2	2	13	1	1
Total served and with treatment:	40	86	152	157	155	168	168
Secondary treatment	NA	NA	56	63	63	71	71
Advanced secondary treatment or tertiary treatment	4	NA	49	48	48	60	60
Nondischarge	NA	NA	NA	5	5	5	6

Data for 1960 and 1970 are not strictly comparable to 1978 and 1980 data because of different methods of data collection. Data for 1960 and 1970 were aggregated by state from the national population censuses. Data for 1978 and 1980 were compiled from the EPA inventories of municipal wastewater facilities.

In 1980, there were more than 32,000 wastewater facilities in operation throughout the country removing some 76% (9 million pounds per day) of bod5 and 80% (also 9 million pounds per day) of suspended solids. bod5 is the amount of oxygen consumed metabolically by test microorganisms in a sample in five days.

NA - Not available.

[1]Primary treatment for 1978 and 1980 also includes the population served by wastewater treatment systems that have no discharges to surface waters. In 1980, this included 4 million people.

[2]Decrease in 1980 due to some tertiary plants being downgraded.

Sources:

1960 and 1970: K.L. Kollar, "Market for Water and Wastewater Treatment Equipment," *J. Water Pollution Control Fed.* 51:682 (1979).

1978 - 1984: U.S. Environmental Protection Agency, Office of Water Program Operations, *1984 Needs Survey Report* (Washington, D.C.: February 1985), and prior reports.

Production of Selected Industrial Chemicals, 1950–1982
(million pounds)

Year	Benzene	Acrylonitrile	Asbestos (demand)	Phthalates	PCBs[1]	Vinyl chloride
1950	1,340	NA	NA	143	NA	250
1955	2,248	118	1,724	213	NA	529
1960	3,343	229	1,418	345	38	1,037
1961	3,987	250	1,332	377	37	1,044
1962	3,994	360	1,453	470	38	1,311
1963	4,733	455	1,449	522	45	1,435
1964	5,338	594	1,627	601	51	1,615
1965	6,045	772	1,590	679	61	2,000
1966	6,983	716	1,610	755	66	2,500
1967	7,086	671	1,442	784	75	2,424
1968	7,311	1,021	1,634	841	83	2,969
1969	8,665	1,157	1,568	884	76	3,736
1970	8,286	1,039	1,469	855	85	4,040
1971	7,865	979	1,519	978	41	4,336
1972	9,155	1,115	1,618	1,146	39	5,088
1973	10,623	1,354	1,753	1,203	42	5,351
1974	10,879	1,412	1,693	1,207	41	5,621
1975	7,485	1,215	1,544	904	30	4,196
1976	10,418	1,518	1,455	1,043	30	5,677
1977	10,495	1,646	1,343	1,202	13	5,986
1978	10,880	1,752	1,365	1,259	0	6,941

Production of Selected Industrial Chemicals, 1950–1982—Continued
(million pounds)

Table A-8
Hazardous chemicals

Year	Benzene	Acrylonitrile	Asbestos (demand)	Phthalates	PCBs[1]	Vinyl chloride
1979	12,227	2,018	1,237	1,291	0	6,389
1980	11,228	1,830	791	1,054	0	6,466
1981	9,573	1,996	769	1,120	0	6,873
1982	7,823	2,035	543	952	0	4,902

NA - Not available.
[1]After 1977, PCBs (polychlorinated biphenyls) were no longer produced in the United States.

Sources:
Benzene, acrylonitrile, phthalates, vinyl chloride: U.S. International Trade Commission, *Synthetic Organic Chemical, United States Production and Sale, 1982* (Washington: USGPO, 1983), and previous annual issues.
Asbestos, 1955: U.S. Department of the Interior, Bureau of Mines, *Mineral Facts and Problems, 1975 Edition* (Washington: USGPO, 1976), p. 120; 1960–1979: *Mineral Facts and Problems, 1980 Edition* (Washington: USGPO, 1981), p. 70; 1981: U.S. Department of the Interior, Bureau of Mines, *Asbestos Minerals Yearbook* (Washington: USGPO, 1981); 1982: U.S. Department of the Interior, Bureau of Mines, *Asbestos Minerals Yearbook* (Washington: USGPO, 1982).
PCBs, 1960–1971: Interdepartmental Task Force on PCBs *Polychlorinated Biphenyls and the Environment* (Washington, D.C.: 1972), pp. 6, 7; 1972–1977: Monsanto Industrial Chemical Company, unpublished data.

Primary Demand[1] for Selected Metals, 1954–1982
(million pounds)

Year	Lead	Chromium	Nickel	Arsenic	Cadmium	Mercury	Year	Lead	Chromium	Nickel	Arsenic	Cadmium	Mercury
1954	1,336	530	167.8	24.8	7.4	2.8	1968	1,816	916	324.4	47.8	13.3	4.9
1955	1,260	923	174.2	28.6	10.6	3.6	1969	1,782	960	304.8	41.2	15.1	5.1
1956	1,268	1,098	238.6	38.4	12.5	3.7	1970	1,658	982	349.4	40.6	9.1	4.1
1957	1,178	1,058	222.0	34.8	10.8	3.6	1971	1,885	682	271.0	39.3	10.9	3.1
1958	1,072	732	119.8	31.0	7.9	3.6	1972	1,907	1,016	335.6	37.9	12.6	3.1
1959	1,195	790	184.6	39.8	11.2	3.8	1973	2,121	1,096	415.2	48.4	12.5	3.5
1960	1,078	706	247.2	37.1	9.8	3.5	1974	1,863	1,120	438.2	55.6	12.1	4.1
1961	1,389	638	268.4	41.9	9.9	3.6	1975	1,444	744	309.0	34.0	6.7	3.3
1962	1,310	566	255.8	41.2	11.9	4.5	1976	1,667	946	333.8	21.4	11.9	4.7
1963	1,350	850	240.0	43.5	11.3	5.4	1977	1,735	1,046	317.6	26.4	8.4	4.2
1964	1,303	1,096	264.2	49.9	8.7	5.6	1978	1,707	1,088	361.0	29.5	9.9	4.2
1965	1,396	1,028	308.8	49.4	10.3	4.5	1979	1,612	1,100	398.4	32.4	11.2	4.4
1966	1,566	1,128	457.6	48.6	14.4	4.8	1980	1,008	980	312.6	27.7	7.8	4.0
1967	1,497	858	365.6	53.4	11.1	4.5	1981[2]	1,243	906	289.5	44.9	9.7	4.2
							1982[2]	1,303	542	207.9	36.8	8.2	3.4

[1]Primary demand is the amount of new materials entering use each year; that is, the apparent consumption minus the amount shipped from Government stockpile excesses, excluding recycled scrap.

[2]Based on U.S. Department of the Interior, Bureau of Mines, 1982 Minerals Yearbook (Washington: USGPO, 1983).

Sources:

Lead, 1954–1957: U.S. Department of the Interior, Bureau of Mines, *Lead—1977,* Mineral Commodity Profiles MCP-9 (Washington: Bureau of Mines, 1977), p. 21. *1958–1979:* U.S. Department of the Interior, Bureau of Mines, *Mineral Facts and Problems, 1980 Edition* (Washington: USGPO, 1981), p. 508.

Chromium, 1954–1957: U.S. Department of the Interior, Bureau of Mines, *Chromium—1977,* Mineral Commodity Profiles MCP-1 (Washington: Bureau of Mines, 1977), p. 14. *1958–1979: Mineral Facts and Problems, 1980 Edition* (Washington: USGPO, 1981), p. 181.

Primary Demand[1] for Selected Metals, 1954–1982—Continued
(million pounds)

Nickel, 1954–1957: U.S. Department of the Interior, Bureau of Mines, *Nickel,* Mineral Commodity Profiles (Washington: Bureau of Mines, 1979), p. 18. *1958–1979: Mineral Facts and Problems, 1980 Edition* (Washington: USGPO, 1981), p. 626.

Arsenic, 1954–1957: Mineral Facts and Problems, 1975 Edition (Washington: USGPO, 1976), p. 105 *1958–1979: Mineral Facts and Problems, 1980 Edition* (Washington: USGPO, 1981), p. 53.

Cadmium, 1954–1957: Mineral Facts and Problems, 1975 Edition (Washington: USGPO, 1976), p. 203. *1958–1979: Mineral Facts and Problems, 1980 Edition* (Washington: USGPO, 1981), p. 140.

Mercury, 1954–1957: Mineral Facts and Problems, 1975 Edition (Washington: USGPO, 1976), p. 681 *1958–1979: Mineral Facts and Problems, 1980 Edition* (Washington: USGPO, 1981) p. 573.

Selected Herbicides Used by Farmers on Crops, 1964–1982

Herbicide	Pounds used (million)	Acres treated (million)	Pounds per acre
All herbicides, total:			
1964	76	NA	NA
1966	112	99	1.1
1971	224	158	1.4
1976	394	197	2.0
1982[1]	433	362	1.2
Atrazine:			
1964	11	8	1.4
1966	23	15	1.6
1971	57	40	1.4
1976	90	62	1.5
19821	75	52	1.4
Alachlor:			
1964	NA	NA	NA
1966	NA	NA	NA
1971	15	12	1.3
1976	89	54	1.7
1982[1]	83	45	1.8
2,4-D:			
1964	30	56	0.5
1966	40	57	0.7
1971	33	55	0.6
1976	38	59	0.7

Selected Herbicides Used by Farmers on Crops, 1964–1982—Continued

Herbicide	Pounds used (million)	Acres treated (million)	Pounds per acre
1982[1]	21	43	0.5
Trifluralin:			
1964	NA	NA	NA
1966	5	7	0.7
1971	11	17	0.7
1976	28	34	0.8
1982[1]	35	41	0.9
All other:			
1964	36	NA	NA
1966	44	NA	NA
1971	107	NA	NA
1976	149	NA	NA
1982[1]	165	166	1.0

Details may not add to totals due to independent rounding.
NA - Not available.
[1]Preliminary data.

Sources:
1964: U.S. Department of Agriculture, Economic Research Service, *Quantities of Pesticides Used by Farmers in 1964*, agr. econ. rep. 131 (Washington: USGPO, 1968), pp. 19, 20;
1966: U.S. Department of Agriculture, Economic Research Service, *Quantities of Pesticides Used by Farmers in 1966*, agr. econ. rep. 179 (Washington: USGPO, 1970), pp. 37, 38, 44;
1971: U.S. Department of Agriculture, Economic Research Service, *Farmers' Use of Pesticides in 1971 — Quantities*, agr. econ. rep. 252 (Washington: USGPO, 1974), pp. 9, 40, 41;
1976: U.S. Department of Agriculture, Economics, Statistics, and Cooperatives Service, *Farmers' Use of Pesticides in 1976*, agr. econ. rep. 418 (Washington: USGPO, 1978), pp. 9, 36, 38;
1982: U.S. Department of Agriculture, Economic Research Service, *1982 Crop and Livestock Pesticide Use Survey*.

Toxic Residues in Fish, 1970–1981
(parts per million, geometric mean)

Toxic residue	1970	1971	1972	1973	1974	1976–1977	1978–1979	1980–1981
DDT[1]	0.98	0.73	0.64	0.44	0.52	0.27	0.25	0.20
PCB	1.20	1.03	1.20	.78	.95	.88	.85	.53
Toxaphene	NA	.01	.13	.17	.17	.35	.29	.27
Dieldrin and aldrin	.08	.07	.07	.05	.09	.05	.05	.04

Freshwater fish samples are collected by Fish and Wildlife Service personnel in all 50 States as part of the National Pesticide Monitoring Program. Two-thirds of the fish sampled are bottom-dwelling species such as carp, suckers, or catfish. The remaining one-third of the fish sampled are predacious species, such as trout, wall-eye, bass, and bluegill. The whole fish is analyzed, not just the fillet.

NA - Not available. Data for 1970–1974 were collected annually. Data for 1976–1981 were collected on a 2-year sampling cycle.

[1]Includes DDT and its derivatives.

Source: U.S. Department of the Interior, Fish and Wildlife Service, Columbia National Fisheries Laboratory, unpublished data.

Selected Insecticides Used by Farmers on Crops, 1964–1982

Insecticide	Pounds used (million)	Acres treated (million)	Pounds per acre
All insecticides total:			
1964	143	NA	NA
1966	138	43	3.3
1971	154	57	2.7
1976	162	75	2.2
1982[1]	59	62	1.0
Toxaphene:			
1964	34	8	4.3
1966	31	5	5.8
1971	33	6	5.9
1976	31	5	6.3
1982[1]	3	2	1.5
Methyl parathion:			
1964	10	7	1.5
1966	8	5	1.8
1971	28	12	2.3
1976	23	12	1.9
1982[1]	9	6	1.5
DDT:[2]			
1964	35	12	2.9
1966	29	9	3.3

Insecticide	Pounds used (million)	Acres treated (million)	Pounds per acre
1971	14	3	4.5
1976	X	X	X
1982[1]	X	X	X
Carbofuran:			
1964	NA	NA	NA
1966	NA	NA	NA
1971	3	4	0.8
1976	12	11	1.0
1982[1]	7	7	1.0
Ethyl parathion:			
1964	6	5	1.3
1966	8	6	1.4
1971	9	10	0.9
1976	7	12	0.5
1982[1]	NA	NA	NA
Aldrin/Dieldrin:			
1964	12	14	0.8
1966	15	15	1.1
1971	8	8	1.0
1976	0.9[3]	0.5[3]	1.9[3]
1982[1]	X	X	X

Selected Insecticides Used by Farmers on Crops, 1964–1982—Continued

Insecticide	Pounds used (million)	Acres treated (million)	Pounds per acre
All other:			
1964	46	NA	NA
1966	46	NA	NA
1971	59	NA	NA
1976	90	NA	NA
1982[1]	NA	NA	NA

Details may not add to totals due to independent rounding.
NA - Not available.
X - Not applicable due to restrictions on use.
DDT was banned for most uses in 1972, and aldrin/dieldrin in 1974.
[1]Preliminary data.
[2]DDT includes its related compound TDE.
[3]Aldrin/dieldrin use in 1976 includes aldrin only. Because aldrin rapidly breaks down into its metabolite, dieldrin, most residues are dieldrin.

Sources:
1964: U.S. Department of Agriculture, Economic Research Service, *Quantities of Pesticides Used by Farmers in 1964,* agr. econ. rep. 131 (Washington: USGPO, 1968), pp. 26, 27;
1966: U.S. Department of Agriculture, Economic Research Service, *Quantities of Pesticides Used by Farmers in 1966,* agr. econ. rep. 179 (Washington: USGPO, 1970), pp. 30–55;
1971: U.S. Department of Agriculture, Economic Research Service, *Farmers' Use of Pesticide in 1971 —Quantities,* agr. econ. rep. 252 (Washington: USGPO, 1974), pp. 13, 50;
1976: U.S. Department of Agriculture, Economics, Statistics, and Cooperatives Service, *Farmers' Use of Pesticides in 1976,* agr. econ. rep. 418 (Washington: USGPO, 1978), pp. 15, 48, 52;
1982: U.S. Department of Agriculture, Economic Research Service, *1982 Crop and Livestock Pesticide Use Survey.*

Toxic Residues in Waterfowl, by Flyway, 1966–1982
(parts per million, mean wet weight)

Table A-13
Hazardous chemicals

Year	Pacific flyway			Central flyway			Mississippi flyway			Atlantic flyway		
	DDE[1]	Dieldrin	PCBs	DDE[1]	Dieldrin	PCBs	DDE[1]	Dieldrin	PCBs	DDE[1]	Dieldrin	PCBs
1966	0.65	<.01	NA	0.15	<.01	NA	0.25	<.01	NA	0.70	<.01	NA
1969	0.71	0.02	0.20	0.30	0.02	0.20	0.40	0.04	0.44	1.03	0.05	1.29
1972	0.34	0.01	0.11	0.15	0.02	0.10	0.37	0.02	0.66	0.44	0.02	1.24
1976	0.22	0.02	0.16	0.28	0.03	0.15	0.25	0.05	0.23	0.32	0.06	0.52
1979	0.35	0.02	0.07	0.10	0.02	0.06	0.17	0.05	0.11	0.27	0.05	0.45
1982	0.36	NA	0.07	0.11	NA	0.05	0.13	NA	0.14	0.25	NA	0.39

NA - Not available.
Waterfowl residues were sampled in the 48 States as part of the National Pesticides Monitoring Program. Wings were removed and analyzed.
[1]DDE is a derivative of DDT.

Sources:
1966: Based on Charles R. Walker, U.S. Fish and Wildlife Service, "Occurrences of PCB in National Fish and Wildlife Monitoring Program."
1969: Donald H. White and Robert G. Heath, "Nationwide Residues of Organochlorines in Wings of Adult Mallards and Black Ducks, 1972–1973," *Pesticides Monitoring Journal* 9:184 (1976).
1972–1976: Donald H. White, "Nationwide Residues of Organochlorines in Wings of Adult Mallards and Black Ducks, 1976," Pesticides Monitoring Journal 13:16 (1979).
1979: Brian W. Cain, U.S. Fish and Wildlife Service, Patuxent Wildlife Research Center, "Nationwide Residues of Organochlorine Compounds in Wings of Adult Mallard and Black Ducks, 1979–1980."
1982: U.S. Fish and Wildlife Service, Patuxent Wildlife Research Center, unpublished data.

Toxic Residues in Humans 1970–1983[1]
Parts per million, geometric mean, lipid basis

Table A-14
Hazardous chemicals

Year	Number of Specimens	Total DDT[2]	Dieldrin	Oxychlordane	Heptachlor Epoxide	Trans-Nonachlor	Beta-Benzene Hexachloride	Hexachlorobenzene
1970	1.386	7.95	.16	N/A	.09	N/A	.37	N/A
1971	1.560	8.06	.22	N/A	.09	N/A	.35	N/A
1972	1.886	6.97	.18	.10	.07	N/A	.19	N/A
1973	1.092	5.96	.17	.12	.09	N/A	.25	N/A
1974	901	5.15	.14	.12	.08	.11	.21	.03
1975	779	4.76	.12	.11	.08	.06	.19	.04
1976	683	4.34	.09	.11	.08	.13	.18	.04
1977	790	3.15	.09	.10	.07	.10	.14	.04
1978	826	3.52	.09	.11	.07	.12	.14	.04
1979	795	3.10	.08	.10	.07	.12	.15	.04
1980	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1981	407	2.38	.05	.09	.11	.13	.10	.04
1982	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1983	383	1.63	.06	.10	.09	.12	.08	.03

[1]Data are for fiscal years. Pesticide residues for selected organochlorine compounds were measured in adipose tissue in 48 States as part of the National Human Adipose Tissue Survey. Specimens were collected each year by medical pathologists from selected cities. Individuals with known or suspected pesticide poisoning were excluded. Data are lipid adjusted, design file specimens only.
[2]DDT includes its metabolites.

Sources:
The data in this table differ slightly from previously published reports due to a change in the geometric mean calculation.
DDT, heptachlor epoxide, oxychlordane, dieldrin, BHC 1970–1975: F. W. Kutz, S.C. Strassman, and J.F. Sperling, "Survey of Selected Organochlorine Pesticides in the General Population of the United States: Fiscal Years 1970–75," Annals of the New York Academy of Sciences 320: 60–68 (May 31, 1979), *1976–1977:* S. C. Strassman and F. W. Kutz, "Trends in Organochlorine Pesticide Residues in Human Tissue" (in press). *1978–1979:* U.S. Environmental Protection Agency, National Human Adipose Tissue Survey, unpublished data.
PCBs, 1972: F. W. Kutz, A. R. Yobs, and S. C. Strassman, "Organochlorine Pesticide Residues in Human Adipose Tissue," 4–19 (1976).
1973–1979: U.S. Environmental Protection Agency, National Human Adipose Tissue Survey, unpublished data.
1970–1983: Unpublished EPA data.

Table A-15
Radiation

Radioactive Levels from Nuclear Fallout and Power Generation, as Measured by Ambient Concentrations of Pollutants, 1960–1984

Year	Strontium-901 in pico curies/liter	Cesium-1371 in pico curies/liter	Krypton-852 in pico curies/cubic meter
1960	8.6	18	NA
1961	8.0	11	NA
1962	13.4	44	7.5
1963	23.5	108	9.0
1964	23.8	109	9.5
1965	17.6	58	10.0
1966	13.3	29	11.0
1967	10.2	16	11.5
1968	8.9	11	12.5
1969	7.5	9	13.5
1970	7.3	8	15.4
1971	6.8	9	14.8
1972	5.6	6	14.9
1973	4.4	5	16.7
1974	4.7	8	17.0
1975	3.9	9	17.5
1976	3.5	7	17.3
1977	3.6	6	17.4 ± 1.7
1978	3.8	7.3	NA
1979	3.5	4.2	21.8 ± 2.2
1980	2.8	3.5	NA
1981	3.0	2.8	NA

Radioactive Levels from Nuclear Fallout and Power Generation, as Measured by Ambient Concentrations of Pollutants, 1960–1984—Continued

Year	Strontium-90[1] in pico curies/liter	Cesium-137[1] in pico curies/liter	Krypton-85[2] in pico curies/cubic meter
1982	2.7	3.8	NA
1983	2.3	1.4	27.4
1984	2.0	3.0	NA

Data aggregated in network averages.
NA - Not available.
[1]Strontium–90 and cesium–137 were measured in pasteurized milk. They were initially released into the atmosphere from weapons testing, distributed worldwide, and then deposited. Values are arithmetic means for all reporting locations.
[2]Krypton–85 was measured in ambient air. This radionuclide is produced as a by-product of the nuclear power industry.

Sources:
Strontium-90 and cesium-137: U.S. Environmental Protection Agency, Eastern Environmental Radiation Facility, unpublished data. Data from individual network stations in Eastern Environmental Radiation Facility, Environmental Radiation Data Report, various quarterly issues.
Krypton-85, 1962–1969: Based on U.S. Environmental Protection Agency, *Radiological Quality of the Environment in the United States, 1977* (Washington: USGPO, 1977), Fig. 2-9, p. 44. *1970–1982:* U.S. Environmental Protection Agency, Eastern Environmental Radiation Facility, unpublished data. *1983–1984:* Data from individual network stations in Radiation Data Report, various quarterly issues.

Air and Water Pollution Removed by Industry, 1980–1983[1]
(thousand short tons)

Industry	Quantity of air pollutants removed				Quantity of water pollutants removed[4]				
	Particulates	Sulfur oxides	Nitrogen oxides, hydrocarbons, carbon monoxide	Heavy metals, radioactive and toxic substances[2]	Suspended solids	Biochemical oxygen demand	Chemical oxygen demand	Oil and grease toxic substances	Total Water
All industries[3]									
1980	39,503.0	8,796.0	11,737.4	1,270.0	19,240.6	4,458.7	4,698.5	7,088.9	35,487
1981	37,496.5	8,213.2	12,521.8	1,445.3	12,821.1	4,190.8	4,613.6	5,994.0	27,620
1982	28,608.4	6,474.4	10.611.7	1,373.5	12,522.3	3,435.5	4,032.6	3,748.5	23,739
1983	31,021.9	6,998.2	11,467.3	1,269.2	NA	NA	NA	NA	27,175
Lumber and wood									
1980	1,395.1	0.3	6.9	9.5	131.2	142.0	72.4	20.9	366.5
1981	1,077.9	0.6	5.1	11.0	111.3	69.9	72.5	29.1	282.8
1982	804.9	0.5	14.0	20.4	78.4	49.0	47.2	20.0	194.6
1983	731.2	0.8	41.0	17.6	NA	NA	NA	NA	473.7
Paper									
1980	5,507.4	430.2	103.7	138.6	3,080.2	1,908.0	1,439.7	198.1	6,626.0
1981	5,351.4	430.1	115.4	224.6	3,227.9	2,067.3	1,710.3	65.7	7,071.2
1982	5,718.5	268.8	94.3	263.6	393.5	1,723.1	1,728.7	26.1	3,871.4
1983	6,074.8	320.9	157.9	187.4	NA	NA	NA	NA	6,375.4
Chemicals									
1980	6.618.1	1,060.1	2,262.7	452.9	5,124.0	803.2	1,191.2	2,862.0	9,980.4
1981	4,025.4	712.4	2,509.0	476.4	4,570.4	744.2	1,197.0	2,430.1	8,941.7

Air and Water Pollution Removed by Industry, 1980–1983[1]—Continued
(thousand short tons)

Industry	Quantity of air pollutants removed				Quantity of water pollutants removed[4]				
	Particulates	Sulfur oxides	Nitrogen oxides, hydrocarbons, carbon monoxide	Heavy metals, radioactive and toxic substances[2]	Suspended solids	Biochemical oxygen demand	Chemical oxygen demand	Oil and grease toxic substances	Total Water
1982	3,550.8	626.0	1,886.6	425.0	1,037.6	2,427.6	879.0	1,149.0	5,493.2
1983	4,160.1	603.5	1,873.7	588.3	NA	NA	NA	NA	4,668.1
Petroleum									
1980	753.3	4,358.7	7,663.7	18.1	698.5	453.5	635.6	1,394.7	3,182.3
1981	684.9	4,290.7	8,037.7	12.3	278.1	271.6	359.7	1,303.1	2,212.5
1982	544.5	4,511.7	7,472.2	17.8	175.0	190.1	307.8	1,082.6	1,755.5
1983	1,203.6	714.7	8,469.2	14.8	NA	NA	NA	NA	2,397.5
Stone, Clay, Glass									
1980	14,938.4	150.3	27.3	41.5	1,339.9	24.1	39.7	115.5	1,519.2
1981	16,691.0	148.9	18.7	6.5	1,089.5	21.8	34.7	9.7	1,155.7
1982	11,473.0	57.7	18.2	63.2	295.8	16.7	34.1	23.2	369.8
1983	13,070.9	226.5	53.6	11.0	NA	NA	NA	NA	1,447.3
Primary metal									
1980	7,263.2	2,643.7	1,208.4	445.5	4,728.7	14.3	53.7	757.9	5,554.6
1981	6,761.0	2,488.3	1,310.5	445.6	4,383.7	11.1	49.7	798.0	5,242.5
1982	4,332.4	890.1	777.2	386.6	2,791.5	13.8	19.6	543.5	3,368.4
1983	4,007.0	1,257.5	484.7	362.4	NA	NA	NA	NA	3,996.5

P00000123632

Air and Water Pollution Removed by Industry, 1980-1983[1]—Continued
(thousand short tons)

Industry	Quantity of air pollutants removed				Quantity of water pollutants removed[4]				
	Particulates	Sulfur oxides	Nitrogen oxides, hydrocarbons, carbon monoxide	Heavy metals, radioactive and toxic substances[2]	Suspended solids	Biochemical oxygen demand	Chemical oxygen demand	Oil and grease toxic substances	Total Water
Electric equipment									
1980	180.8	11.3	47.7	17.2	78.6	2.2	3.0	141.5	225.3
1981	188.0	11.7	82.6	28.0	46.9	2.7	6.3	167.9	223.8
1982	160.4	11.5	89.8	13.7	54.7	1.6	5.8	122.1	184.2
1983	137.0	12.1	128.9	4.2	NA	NA	NA	NA	310.9
Transportation equipment									
1980	242.8	37.5	44.2	87.5	612.8	22.4	23.5	222.3	881.0
1981	213.2	38.0	38.0	119.0	322.4	7.7	19.9	214.7	564.7
1982	185.2	32.7	24.1	NA	204.0	16.3	29.0	227.5	476.8
1983	197.5	31.5	33.3	6.2	NA	NA	NA	NA	499.8

[1]Based on probability sample of about 20,000 manufacturing establishments. Excludes apparel and other textile and establishments with less than 20 employees.
[2]Includes other pollutants.
[3]Includes industries not shown separately.
[4]Categories for water pollution changed in 1983 and are not reconcilable with prior years.
NA - Not available.

Source: U.S. Bureau of the Census, *Pollution Abatement Costs and Expenditures, 1983* (Washington, D.C.: April 1985), and prior annual reports.

Solid Waste Removed by Manufacturing Industries, 1974–1983
(million short tons)[1]

SIC Code[2]	Manufacturing industry	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
	Total, manufacturing	133.325	139.051	156.826	159.954	160.753	163.678	149.870	145.797	99.429	89.041
28	Chemicals and allied products	38.155	38.695	50.282	55.719	48.803	45.407	43.431	43.673	36.028	18.816
33	Primary metal industries	40.800	42.708	42.353	41.742	46.068	47.783	37.520	35.967	16.669	17.715
20	Food processing	11.501	12.641	14.965	13.088	13.392	13.971	14.410	13.155	9.783	9.602
32	Stone, clay, glass products ...	9.337	11.345	11.088	12.617	12.742	14.143	13.336	12.098	5.813	6.176
26	Paper and allied products	8.837	9.123	10.146	10.648	10.947	13.253	12.251	11.299	11.452	13.655
24	Lumber and wood products ..	6.887	8.143	9.328	6.311	6.662	6.506	5.863	6.419	3.746	3.994
37	Transportation equipment ...	4.207	3.785	4.284	4.749	5.242	4.253	4.168	3.966	2.893	3.014
35	Machinery, except electrical ..	2.714	2.720	3.067	3.581	3.410	3.524	3.000	2.818	1.630	1.820
29	Petroleum and coal products .	2.388	2.038	2.592	2.873	3.585	3.075	4.873	4.667	4.430	3.550
34	Fabricated metal products	2.127	1.933	2.089	1.951	1.992	2.031	1.864	1.801	1.436	1.951
30	Rubber, miscellaneous plastic products	1.704	1.404	1.676	1.567	2.056	2.873	2.814	2.926	1.543	1.541
36	Electric, electronic equipment	1.534	1.500	1.500	1.495	1.777	2.319	2.148	1.683	1.250	1.704
27	Printing and publishing	.617	.628	.848	.941	.879	1.148	1.177	2.087	.558	3.227
22	Textile mill products	.750	.668	.671	.825	1.180	1.101	.810	1.144	.845	.691
25	Furniture and fixtures	.517	.592	.638	.668	.705	.736	.668	.621	.346	.296
38	Instruments, related products .	.552	.409	.396	.418	.401	.427	.480	.466	.448	569
31	Leather and leather products .	.233	.221	.385	.291	.290	.360	.340	.295	.179	.224

Solid Waste Removed by Manufacturing Industries, 1974–1983—Continued
(million short tons)[1]

SIC Code[2]	Manufacturing industry	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
39	Miscellaneous manufacturing industries	.319	.350	.352	.335	.440	.597	.527	.538	.183	.296
21	Tobacco products	.148	.150	.164	.136	.183	.148	.157	.174	.190	.222

Data include solid wastes properly removed of by means acceptable to local, state, and federal authorities. Recovered materials are excluded.
Details may not add to totals due to independent rounding.
[1]The aggregated data are composed partially of wet weight and partially of dry weight figures.
[2]Standard Industrial Classification code.

Sources: U.S. Bureau of the Census, *Pollution Abatement Costs and Expenditures, 1983* (Washington, D.C.: April 1985), and prior annual reports.

Low-level Radioactive Wastes Disposed of, 1962–1983
(thousand cubic meters buried)

Table A-18
Wastes

	Annual Addition			Cumulative buried		
Year	Commercial	U.S. Department of Energy[1]	Total	Commercial	U.S. Department of Energy[1]	Total
1962	1.9	—	—	1.9	—	—
1963	6.2	—	—	8.1	—	—
1964	13.1	—	—	21.2	—	—
1965	13.1	—	—	34.3	—	—
1966	16.2	—	—	50.5	—	—
1967	19.3	—	—	69.8	—	—
1968	20.3	—	—	90.1	—	—
1969	21.6	—	—	111.7	—	—
1970	26.0	—	—	137.7	—	—
1971	30.6	—	—	168.4	—	—
1972	37.3	—	—	205.7	—	—
1973	47.0	—	—	252.7	—	—
1974	53.6	—	—	306.3	—	—
1975	57.6	—	—	363.9	1,518	1,882
1976	74.2	56.2	130.4	438.2	1,574	2,012
1977	71.2	44.3	115.5	509.4	1,618	2,127
1978	79.6	60.1	139.7	588.9	1,678	2,267
1979	82.5	84.0	166.5	671.5	1,762	2,434
1980	106.8	57.9	164.7	778.2	1,820	2,598

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Low-level Radioactive Wastes Disposed of, 1962-1983—Continued
(thousand cubic meters buried)

	Annual Addition			Cumulative buried		
Year	Commercial	U.S. Department of Energy[1]	Total	Commercial	U.S. Department of Energy[1]	Total
1981	87.8	62.1	149.9	866.0	1,882	2,748
1982	75.9	89.1	165.0	941.9	1,971	2,913
1983	84.0	89.5	173.5	1,012.5	2,062	3,075

[1]Wastes generated by other federal agencies are buried at commercial sites.

Source: U.S. Department of Energy, Office of Nuclear Energy, *Spent Fuel and Radioactive Waste Inventories, Projections and Characteristics* (Washington, D.C.: DOE/NE-00117-3, September 1984).

National Expenditures for Pollution Abatement and Control, 1972–1983[1]
(billion current dollars and billion 1972 dollars)

Table A-19
Pollution abatement and control expenditures

Category of expenditure	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Total expenditures												
Pollution abatement and control	18.434	21.930	26.261	30.923	34.681	37.962	43.416	49.904	55.368	58.965	58.889	62.658
	18.434	20.603	21.307	23.008	24.325	24.800	26.330	26.936	26.353	25.536	24.304	25.182
Pollution abatement[2]	17.245	20.537	24.678	29.167	32.677	35.652	40.833	47.062	52.350	55.832	55.967	59.836
	19.951	21.644	22.868	23.230	24.696	25.236	25.018	24.721	24.698	23.983	22.955	23.947
Personal consumption	1.536	2.065	2.667	3.463	3.994	4.311	4.762	5.646	6.808	8.361	8.521	9.951
	1.536	1.965	2.116	2.589	2.857	2.945	3.066	3.100	3.211	3.728	3.717	4.376
Durable goods	.476	.670	.690	1.361	1.821	2.166	2.525	2.912	3.557	4.716	4.818	5.980
	.476	.670	.651	1.184	1.489	1.683	1.816	1.943	2.199	2.747	2.702	3.271
Nondurable goods and services	1.060	1.395	1.977	2.102	2.173	2.145	2.237	2.734	3.251	3.645	3.703	3.971
	1.060	1.295	1.465	1.405	1.368	1.262	1.250	1.158	1.012	.982	1.014	1.104
Business	10.960	13.097	15.527	18.134	20.335	22.761	25.692	30.066	33.946	36.886	36.954	39.240
	10.960	12.330	12.372	13.057	13.789	14.315	15.011	15.651	15.409	15.188	14.457	14.945
On capital account	5.399	6.766	7.436	8.832	9.469	10.101	10.882	12.309	12.987	13.386	13.095	12.952
	5.399	6.435	6.200	6.662	6.762	6.760	6.758	6.992	6.734	6.453	5.987	5.811
On current account	5.561	6.331	8.091	9.302	10.866	12.660	14.809	17.757	20.959	23.500	23.859	26.288
	5.561	5.895	6.172	6.395	7.027	7.555	8.253	8.658	8.675	8.734	8.470	9.134
Private	4.838	5.459	6.994	8.100	9.533	11.022	12.833	15.596	18.490	20.586	20.004	21.917
	5.039	5.259	5.520	6.138	6.550	7.135	7.531	7.614	7.526	7.533	7.036	7.562
Government enterprise	1.151	1.342	1.635	1.896	2.221	2.603	3.051	3.522	4.079	4.701	5.318	5.786
	1.151	1.263	1.296	1.330	1.444	1.574	1.705	1.780	1.827	1.893	1.995	2.112
Costs recovered	-.428	-.470	-.538	-.693	-.887	-.966	-1.075	-1.360	-1.610	-1.788	-1.463	-1.415
	-.428	-.407	-.383	-.455	-.555	-.569	-.587	-.653	-.678	-.691	- 562	-.539
Government	4.749	5.375	6.484	7.570	8.348	8.580	10.380	11.350	11.596	10.584	10.492	10.645
	4.749	5.002	5.463	5.988	6.221	5.970	6.619	6.486	6.078	5.067	4.781	4.626
Federal	.139	.203	.294	.432	.472	.490	.472	.548	.494	.506	.552	.808
	.139	.190	.245	.332	.339	.323	.288	.297	.241	.221	.229	.337
State and local	1.311	1.433	1.591	1.752	1.834	1.963	2.212	2.461	2.778	3.053	3.277	3.516
	1.305	1.344	1.349	1.359	1.418	1.428	1.434	1.470	1.430	1.419	1.464	1.507

P00000123638

National Expenditures for Pollution Abatement and Control, 1972–1983[1]—Continued

(billion current dollars and billion 1972 dollars)

Table A-19

Pollution abatement and control expenditures

Category of expenditure	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Government enterprise fixed capital	3.299	3.738	4.598	5.387	6.042	6.128	7.697	8.341	8.324	7.026	6.663	6.321
	3.299	3.482	3.913	4.322	4.534	4.288	4.913	4.761	4.408	3.428	3.088	2.782
Regulation and monitoring	.367	.490	.595	.653	.725	.833	.949	1.067	1.296	1.378	1.397	1.255
	.367	.456	.515	.517	.538	.577	.620	.653	.728	.701	.661	.555
Federal	.200	.278	.346	.381	.402	.429	.507	.593	.793	.818	.820	.669
	.200	.259	.303	.305	.303	.304	.340	.372	.459	.431	.407	.319
State and local	.167	.212	.248	.272	.323	.404	.442	.474	.502	.560	.577	.586
	.167	.197	.212	.213	.234	.274	.280	.281	.269	.270	.254	.236
Research and development	.823	.903	.988	1.103	1.279	1.478	1.633	1.775	1.722	1.756	1.525	1.568
	.823	.849	.840	.847	.920	.993	1.014	1.046	.927	.853	.689	.680
Private	.519	.569	.608	.608	.706	.849	.985	1.143	1.067	1.083	.893	.868
	.519	.535	.512	.461	.501	.562	.604	.654	.564	.516	.394	.367
Federal	.205	.269	.342	.448	.528	.578	.592	.564	.591	.646	.604	.668
	.205	.253	.294	.348	.385	.394	.373	.349	.327	.323	.281	.299
State and local	.099	.065	.039	.047	.045	.051	.057	.069	.064	.028	.028	.032
	.099	.061	.034	.038	.035	.037	.038	.043	.035	.014	.014	.014
Air												
Pollution abatement and control	6.482	8.321	10.446	12.840	14.162	15.581	17.324	21.031	24.890	28.091	27.451	29.189
	6.482	7.832	8.092	9.119	9.546	9.805	10.185	10.749	10.917	11.463	10.836	11.499
Pollution abatement[2]	5.808	7.572	9.665	12.053	13.279	14.536	16.117	19.704	23.582	26.763	26.287	28.032
	5.808	7.130	7.428	8.514	8.912	9.104	9.433	9.975	10.216	10.822	10.315	11.004
Personal consumption	1.536	2.065	2.667	3.463	3.994	4.311	4.762	5.646	6.808	8.361	8.521	9.951
	1.536	1.965	2.116	2.589	2.857	2.945	3.066	3.100	3.211	3.728	3.717	4.376
Durable goods	.476	.670	.690	1.361	1.821	2.166	2.525	2.912	3.557	4.716	4.818	5.980
	.476	.670	.651	1.184	1.489	1.683	1.816	1.943	2.199	2.747	2.702	3.271
Nondurable goods and services	1.060	1.395	1.977	2.102	2.173	2.145	2.237	2.734	3.251	3.645	3.703	3.971
	1.060	1.295	1.465	1.405	1.368	1.262	1.250	1.158	1.012	.981	1.014	1.104

National Expenditures for Pollution Abatement and Control, 1972–1983[1]—Continued **Table A-19**

(billion current dollars and billion 1972 dollars) Pollution abatement and control expenditures

Category of expenditure	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Business	4.153	5.378	6.840	8.403	9.029	9.930	11.072	13.691	16.302	17.911	17.238	17.582
	4.153	5.042	5.186	5.793	5.884	5.977	6.204	6.683	6.782	6.878	6.378	6.428
On capital account	2.366	3.264	3.810	4.790	4.774	4.956	5.317	6.317	7.074	7.810	7.550	7.222
	2.366	3.124	3.164	3.596	3.425	3.357	3.384	3.705	3.774	3.906	3.598	3.466
On current account	1.787	2.114	3.029	3.613	4.255	4.975	5.755	7.373	9.227	10.101	9.688	10.360
	1.787	1.918	2.022	2.197	2.459	2.621	2.820	2.978	3.006	2.972	2.781	2.961
Private	1.764	2.085	2.973	3.568	4.197	4.915	5.683	7.267	9.079	9.966	9.547	10.217
	1.764	1.893	1.996	2.177	2.433	2.595	2.792	2.946	2.968	2.938	2.746	2.927
Government enterprise	.023	.029	.056	.045	.058	.060	.072	.106	.148	.135	.141	.143
	.023	.025	.026	.020	.026	.025	.028	.032	.039	.033	.035	.034
Government	.119	.129	.158	.188	.256	.295	.283	.368	.473	.491	.528	.499
	.119	.123	.127	.133	.171	.181	.163	.192	.224	.216	.220	.201
Federal	.056	.047	.056	.088	.105	.106	.090	.103	.095	.085	.087	.131
	.056	.045	.044	.061	.068	.061	.048	.048	.039	.031	.031	.045
State and local	(*)	(*)	(*)	.001	.001	.001	(*)	(*)	(*)	(*)	(*)	(*)
	(*)	(*)	(*)	(*)	.001	.001	(*)	(*)	(*)	(*)	(*)	(*)
Government enterprise fixed capital	.063	.082	.102	.100	.150	.188	.193	.265	.378	.406	.441	.369
	.063	.078	.082	.071	.103	.120	.115	.185	.185	.185	.189	.156
Regulation and monitoring	.143	.165	.183	.206	.203	.241	.276	.300	.329	.334	.324	.325
	.143	.154	.157	.162	.149	.166	.179	.181	.180	.165	.147	.140
Federal	.048	.050	.052	.066	.069	.080	.093	.100	.122	.108	.093	.086
	.048	.047	.045	.053	.052	.057	.062	.063	.071	.057	.046	.041
State and local	.095	.115	.131	.139	.135	.161	.183	.200	.207	.226	.230	.239
	.095	.107	.112	.109	.098	.109	.116	.118	.109	.108	.101	.099
Research and development	.531	.583	.599	.581	.680	.803	.931	1.027	.979	.995	.841	.831
	.531	.548	.507	.443	.485	.535	.574	.593	.521	.477	.374	.355

National Expenditures for Pollution Abatement and Control, 1972–1983[1]—Continued **Table A-19**

(billion current dollars and billion 1972 dollars) **Pollution abatement and control expenditures**

Category of expenditure	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Private	.411	.451	.492	.464	.543	.653	.777	.915	.845	.863	.713	.691
	.411	.424	.415	.352	.385	.433	.476	.447	.447	.411	.315	.292
Federal	.104	.126	.100	.108	.131	.144	.146	.130	.130	.131	.126	.136
	.104	.118	.086	.084	.095	.098	.092	.065	.072	.066	.058	.061
State and local	.017	.006	.007	.008	.006	.007	.008	.005	.005	(*)	.002	.005
	.017	.006	.006	.006	.005	.005	.005	.005	.003	(*)	.001	.002
Water												
Pollution abatement and control	8.727	10.089	11.634	13.561	15.513	16.838	19.876	21.799	22.436	21.812	22.098	23.585
	8.727	9.459	9.659	10.300	10.985	11.031	11.954	11.832	11.014	9.655	9.209	9.350
Pollution abatement[2]	8.440	9.731	11.235	13.117	15.006	16.268	19.253	21.126	21.685	21.059	21.373	22.841
	8.440	9.124	9.315	9.952	10.613	10.641	11.554	11.422	10.596	9.276	8.871	9.026
Business	4.957	5.770	6.354	7.349	8.653	9.862	11.215	12.446	13.165	13.933	14.362	16.165
	4.957	5.441	5.182	5.340	5.850	6.165	6.455	6.457	6.116	5.815	5.739	6.090
On capital account	2.723	3.158	3.205	3.627	4.229	4.625	4.984	5.268	5.076	4.665	4.709	5.001
	2.723	2.981	2.683	2.758	3.008	3.063	3.028	2.902	2.563	2.151	2.046	2.057
On current account	2.235	2.612	3.149	3.722	4.424	5.237	6.231	7.178	8.089	9.268	9.923	11.164
	2.235	2.460	2.499	2.582	2.842	3.103	3.428	3.596	3.553	3.664	3.693	4.033
Private	1.107	1.299	1.572	1.872	2.262	2.694	3.253	3.763	4.159	4.702	4.745	5.552
	1.107	1.221	1.230	1.273	1.424	1.555	1.751	1.848	1.766	1.805	1.732	1.956
Government enterprise	1.128	1.313	1.577	1.850	2.162	2.543	2.987	3.415	3.930	4.565	5.177	5.643
	1.128	1.239	1.269	1.309	1.418	1.548	1.676	1.748	1.787	1.859	1.961	2.077
Government	3.483	3.961	4.881	5.768	6.353	6.406	8.038	8.681	8.520	7.126	6.741	6.676
	3.483	3.683	4.133	4.612	4.763	4.476	5.099	4.925	4.480	3.461	3.132	2.936
Federal	.075	.133	.196	.271	.257	.279	.316	.347	.274	.220	.240	.399
	.075	.124	.165	.214	.189	.191	.198	.194	.139	.101	.106	.175
State and local	.171	.171	.189	.210	.204	.188	.218	.257	.299	.286	.279	.324
	.171	.155	.137	.147	.142	.117	.102	.115	.118	.117	.127	.134

National Expenditures for Pollution Abatement and Control, 1972–1983[1]—Continued **Table A-19**
(billion current dollars and billion 1972 dollars) **Pollution abatement and control expenditures**

Category of expenditure	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Government enterprise fixed capital	3.237	3.657	4.496	5.287	5.892	5.939	7.540	8.076	7.946	6.620	6.222	5.953
	3.237	3.404	3.831	4.251	4.432	4.169	4.799	4.617	4.223	3.243	2.899	2.627
Regulation and monitoring	.144	.190	.247	.279	.328	.370	.405	.425	.525	.516	.497	.498
	.144	.177	.214	.221	.242	.255	.263	.261	.295	.262	.234	.216
Federal	.079	.099	.135	.153	.151	.146	.186	.232	.326	.296	.272	.266
	.079	.092	.118	.122	.114	.103	.125	.145	.189	.156	.135	.126
State and local	.066	.091	.112	.126	.177	.224	.219	.193	.199	.220	.225	.232
	.066	.085	.096	.099	.128	.152	.139	.115	.107	.107	.100	.090
Research and development	.142	.168	.153	.165	.180	.200	.219	.248	.226	.238	.229	.246
	.142	.158	.130	.127	.130	.135	.137	.149	.123	.117	.105	.108
Private	.064	.073	.057	.069	.078	.092	.099	.111	.109	.108	.088	.087
	.064	.069	.048	.052	.055	.061	.061	.063	.057	.051	.039	.037
Federal	.034	.062	.078	.077	.084	.090	.104	.118	.095	.119	.131	.150
	.034	.059	.067	.060	.061	.061	.065	.073	.053	.059	.061	.067
State and local	.044	.033	.018	.019	.018	.018	.017	.019	.023	.011	.010	.009
	.044	.031	.016	.015	.014	.013	.011	.012	.013	.006	.005	.004
Solid waste												
Pollution abatement and control	3.462	3.745	4.373	4.741	5.286	5.828	6.609	7.664	8.796	9.916	9.871	10.386
	3.462	3.489	3.640	3.672	3.902	4.065	4.342	4.540	4.627	4.649	4.395	4.469
Pollution abatement[2]	3.421	3.697	4.311	4.666	5.220	5.750	6.518	7.536	8.614	9.635	9.564	10.118
	3.421	3.445	3.587	3.613	3.854	4.012	4.284	4.462	4.526	4.505	4.248	4.349
Business	2.277	2.419	2.870	3.075	3.539	3.933	4.479	5.289	6.089	6.829	6.547	6.907
	2.277	2.254	2.387	2.378	2.610	2.740	2.938	3.124	3.190	3.185	2.902	2.966
On capital account	.310	.344	.421	.415	.466	.520	.582	.724	.836	.911	.836	.729
	.310	.330	.353	.308	.329	.340	.346	.386	.398	.396	.344	.287
On current account	1.967	2.075	2.450	2.660	3.074	3.413	3.897	4.566	5.252	5.918	5.711	6.179
	1.967	1.925	2.034	2.070	2.281	2.400	2.593	2.738	2.792	2.790	2.588	2.679

National Expenditures for Pollution Abatement and Control, 1972-1983[1]—Continued

(billion current dollars and billion 1972 dollars)

Table A-19

Pollution abatement and control expenditures

Category of expenditure	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Private	1.967	2.074	2.450	2.659	3.074	3.413	3.897	4.566	5.252	5.918	5.711	6.178
	1.967	1.925	2.034	2.070	2.281	2.400	2.593	2.738	2.792	2.790	2.558	2.679
Government enterprise	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)
	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)
Government	1.144	1.278	1.441	1.591	1.681	1.817	2.039	2.246	2.525	2.806	3.017	3.211
	1.144	1.190	1.200	1.235	1.243	1.271	1.345	1.338	1.336	1.320	1.346	1.383
Federal	.005	.016	.039	.050	.052	.043	.047	.048	.055	.053	.057	.089
	.005	.016	.032	.038	.038	.030	.030	.028	.028	.025	.025	.038
State and local	1.140	1.262	1.403	1.541	1.629	1.774	1.992	2.198	2.470	2.752	2.960	3.122
	1.140	1.175	1.168	1.197	1.206	1.242	1.315	1.310	1.308	1.295	1.321	1.344
Regulation and monitoring	.014	.018	.027	.032	.028	.039	.055	.086	.129	.218	.242	.189
	.014	.017	.023	.026	.021	.027	.036	.052	.072	.112	.118	.085
Federal	.009	.014	.022	.026	.021	.026	.028	.037	.066	.143	.190	.106
	.009	.013	.019	.021	.016	.018	.019	.023	.038	.075	.094	.051
State and local	.005	.004	.005	.006	.007	.014	.028	.049	.063	.075	.052	.082
	.005	.003	.004	.005	.005	.009	.017	.029	.034	.037	.023	.035
Research and development	.027	.030	.035	.043	.039	.039	.035	.043	.053	.064	.064	.079
	.027	.028	.030	.033	.028	.026	.022	.026	.029	.031	.030	.035
Private	.012	.010	.013	.022	.020	.021	.016	.015	.018	.016	.013	.013
	.012	.009	.011	.017	.014	.014	.010	.009	.010	.008	.006	.006
Federal	.006	.011	.017	.015	.014	.014	.016	.024	.032	.044	.048	.061
	.006	.011	.015	.011	.010	.010	.010	.015	.018	.022	.022	.027
State and local	.010	.009	.005	.006	.004	.004	.004	.004	.003	.004	.004	.005
	.010	.008	.004	.005	.003	.003	.003	.002	.002	.002	.002	.002
Other and unallocated[3]												
Pollution abatement and control	-.236	-.225	-.193	-.219	-.280	-.285	-.394	-.590	-.754	-.854	-.530	-.501
	-.236	-.177	-.085	-.083	-.108	-.101	-.150	-.184	-.205	-.213	-.135	-.136
Pollution abatement[2]	-.424	-.463	-.533	-.669	-.828	-.903	-1.055	-1.304	-1.531	-1.625	-1.256	-1.156
	-.424	-.401	-.378	-.435	-.511	-.527	-.574	-.623	-.640	-.621	-.478	-.433

National Expenditures for Pollution Abatement and Control, 1972–1983[1]—Continued **Table A-19**
(billion current dollars and billion 1972 dollars) **Pollution abatement and control expenditures**

Category of expenditure	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Business	–.428	–.470	–.537	–.692	–.887	–.965	–1.075	–1.359	–1.609	–1.787	–1.463	–1.415
	–.428	–.407	–.382	–.484	–.555	–.568	–.586	–.653	–.678	–.691	–.562	–.539
On current account	–.428	–.470	–.537	–.692	–.887	–.965	–1.075	–1.359	–1.609	–1.787	–1.463	–1.415
	–.428	–.407	–.382	–.454	–.555	–.568	–.586	–.653	–.678	– .691	–.562	–.539
Government enterprise	(*)	(*)	.002	.001	.001	.001	(*)	.001	.001	.001	(*)	(*)
	(*)	(*)	.001	(*)	.001	.001	(*)	(*)	(*)	(*)	(*)	(*)
Cost recovered	–.428	–.470	–.538	–.693	–.887	–.966	–1.075	–1.360	–1.610	–1.788	–1.463	–1.415
	–.428	–.407	–.383	–.455	–.555	–.569	–.587	–.653	–.678	–.691	–.562	–.539
Government	.003	.006	.004	.023	.059	.062	.020	.055	.079	.162	.206	.259
	.003	.006	.003	.019	.044	.042	.012	.030	.038	.070	.084	.107
Federal	.003	.006	.004	.023	.059	.062	.019	.050	.070	.148	.168	.190
	.003	.006	.003	.019	.044	.041	.011	.027	.034	.064	.068	.078
State and local	(*)	(*)	(*)	(*)	(*)	(*)	.001	.006	.009	.014	.038	.069
	(*)	(*)	(*)	(*)	(*)	(*)	.001	.003	.004	.006	.016	.028
Regulation and monitoring	.066	.117	.138	.136	.167	.182	.213	.257	.313	.311	.335	.243
	.066	.109	.121	.109	.126	.129	.142	.160	.181	.162	.162	.114
Federal	.064	.115	.138	.136	.162	.177	.201	.225	.280	.272	.265	.211
	.064	.107	.121	.108	.122	.126	.134	.141	.162	.143	.131	.100
State and local	.002	.002	(*)	(*)	.005	.005	.012	.032	.034	.039	.070	.033
	.002	.002	(*)	(*)	.003	.003	.008	.019	.019	.019	.031	.014
Research and development	.122	.122	.202	.315	.381	.436	.449	.457	.464	.460	.391	.412
	.122	.115	.173	.244	.277	.297	.282	.278	.254	.228	.180	.183
Private	.032	.035	.046	.052	.065	.083	.093	.102	.096	.095	.079	.077
	.032	.033	.039	.040	.046	.055	.057	.058	.051	.045	.035	.033
Federal	.062	.069	.146	.248	.299	.330	.326	.318	.335	.352	.300	.321
	.062	.065	.126	.192	.218	.225	.206	.196	.185	.176	.139	.144
State and local	.028	.018	.009	.014	.017	.023	.029	.038	.033	.013	.013	.014
	.028	.017	.008	.011	.013	.017	.019	.024	.018	.007	.006	.006

National Expenditures for Pollution Abatement and Control, 1972–1983[1]—Continued

Table A-19

(billion current dollars and billion 1972 dollars)

Pollution abatement and control expenditures

Category of expenditure	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983

[1]Includes expenditures for air and water pollution abatement and control. Includes expenditures for solid waste collection and disposal by means acceptable to federal, state, and local authorities. Excludes agricultural production of crops and livestock except feedlots.

[2]Expenditures are attributed to the sector that performs the air or water pollution abatement or solid waste collection and disposal.

[3]"Other" includes expenditures for abatement and control of noise, radiation, and pesticide pollution; "unallocated" includes business expenditures not assigned to media.

*Less than $500,000.

Source: U.S. Department of Commerce, Bureau of Economic Analysis, "Pollution Abatement and Control Expenditures 1980–1983," *Survey of Current Business* (Washington, D.C.: March 1985), and earlier issues.

Pollution Abatement Expenditures, by Selected Industry, 1973–1983
(million dollars)

Table A-20
Pollution abatement and control expenditures

SIC code[1]	Industry and year	Capital expenditures (PACE)			Solid waste	Gross annual costs (GAC), including payments to government units			Solid waste	Percent change[2] in totals	
		Total	Air	Water		Total	Air	Water		PACE	GAC
	All Industries										
	1978[3]	3,279.3	1,853.6	1,246.5	178.9	6,275.7	2,527.4	2,529.9	1,218.2	–6	16
	1979[3]	3,564.5	2,071.9	1,245.7	246.9	7,399.9	3,061.8	3,015.6	1,322.5	9	18
	1980[3]	3,502.9	2,105.5	1,146.5	251.0	8,141.8	3,297.8	3,193.1	1,650.6	–2	10
	1981[3]	3,484.9	2,193.6	1,028.4	263.1	9,109.9	3,697.8	3,554.3	1,855.7	–1	12
	1982[3]	3,024.1	1,828.2	977.4	218.5	8,565.0	3,455.9	3,488.5	1,619.9	–13	–6
	1983[3]	2,045.0	1,029.0	819.0	197.1	9,925.1	3,806.9	3,943.2	2,175.0	–32	16
28	Chemicals and allied products										
	1973	395.9	164.4	214.6	16.8	502.3	174.1	247.6	80.2	X	X
	1974	539.2	250.6	264.4	24.1	643.3	203.8	335.6	104.0	36	28
	1975	780.2	359.5	385.7	35.0	807.4	249.9	430.9	126.7	45	26
	1976	942.0	319.8	577.4	44.7	983.5	295.6	514.7	173.2	21	22
	1977[3]	982.5	339.9	593.1	49.6	1,238.3	335.5	685.2	217.6	4	26
	1977[4]	1,000.2	346.0	603.8	50.5	1,247.0	337.8	690.0	219.1	6	27
	1978[3]	827.5	376.3	385.9	65.1	1,473.0	398.8	794.1	280.1	–16	19
	1978[4]	842.4	383.3	392.9	66.3	1,483.3	400.8	799.6	282.1	–16	19
	1979[3]	770.9	314.6	360.7	95.6	1,667.5	485.3	895.2	287.0	–7	13
	1979[4]	784.8	320.3	367.2	97.3	1,679.2	488.7	901.5	289.0	–7	13
	1980[3]	780.7	325.9	350.0	104.8	1,851.8	539.9	942.9	368.8	1	11
	1980[3]	794.8	331.7	356.3	106.7	1,864.8	543.8	949.5	371.4	1	11
	1981[3]	752.8	335.0	322.2	95.6	2,047.8	571.7	1,069.1	406.9	–4	11
	1982[3]	627.6	272.8	256.5	98.3	2,106.5	556.1	1,112.3	438.2	–17	3
	1983[3]	395.4	159.0	187.4	49.0	2,198.2	624.9	1,106.0	467.4	–37	4

Pollution Abatement Expenditures, by Selected Industry, 1973-1983—Continued **Table A-20**

(million dollars) **Pollution abatement and control expenditures**

SIC code[1]	Industry and year	Capital expenditures (PACE) Total	Air	Water	Solid waste	Gross annual costs (GAC), including payments to government units Total	Air	Water	Solid waste	Percent change[2] in totals PACE	GAC
29	Petroleum and coal products										
	1973	321.8	222.5	96.1	3.2	337.8	192.5	125.4	19.9	X	X
	1974	462.3	341.3	119.7	1.3	420.1	238.3	153.3	28.5	44	24
	1975	555.7	398.2	155.7	1.7	563.1	339.4	192.1	31.7	20	34
	1976	441.4	236.5	199.8	5.2	774.8	466.1	263.3	45.3	-21	38
	1977[3]	368.5	167.7	195.6	5.3	948.0	601.3	289.3	57.4	-17	22
	1977[4]	369.2	168.0	196.0	5.3	960.3	609.1	293.1	58.1	-16	24
	1978[3]	419.3	311.2	100.5	7.6	997.4	636.4	304.1	57.0	14	5
	1978[4]	420.1	311.8	100.7	7.6	1,010.4	644.7	308.1	57.7	14	5
	1979[3]	534.3	397.8	119.4	17.1	1,173.8	750.7	370.8	52.3	27	18
	1979[4]	535.4	398.6	119.6	17.1	1,189.1	760.5	375.6	53.0	27	18
	1980[3]	531.9	402.3	114.2	15.4	1,418.0	910.1	406.9	101.0	-1	21
	1980[4]	533.6	403.5	114.6	15.4	1,436.4	921.7	412.2	102.3	-1	21
	1981[5]	590.6	440.8	131.7	18.2	1,685.5	1,118.0	437.2	130.2	11	19
	1982[5]	712.1	533.2	165.7	13.1	1,800.8	1,195.1	472.0	133.7	21	7
	1983[5]	485.0	308.2	164.7	12.0	1,893.7	1,203.3	552.3	137.9	-32	5
30	Rubber, miscellaneous plastics products										
	1973	24.2	13.5	7.3	3.3	42.6	12.2	10.1	20.4	X	X
	1974	37.9	22.2	13.5	2.2	58.8	15.7	15.1	28.2	57	38
	1975	31.9	22.2	6.6	3.1	64.8	20.7	18.4	25.7	-16	10
	1976	37.4	24.2	10.0	3.1	80.3	22.3	24.0	34.0	17	24
	1977[3]	36.6	17.4	13.8	5.4	73.8	19.8	18.9	35.1	-2	-8
	1977[4]	36.7	17.4	13.8	5.4	74.9	20.1	19.2	35.6	-2	-7

Pollution Abatement Expenditures, by Selected Industry, 1973–1983—Continued
(million dollars)

SIC code[1]	Industry and year	Capital expenditures (PACE) Total	Air	Water	Solid waste	Gross annual costs (GAC), including payments to government units Total	Air	Water	Solid waste	Percent change[2] in totals PACE	GAC
	1978[3]	27.7	18.7	5.5	3.4	84.9	17.7	23.9	43.3	-24	15
	1978[4]	27.8	18.8	5.5	3.4	86.2	18.0	24.3	44.0	-24	15
	1979[3]	25.1	12.9	9.3	2.9	111.7	32.2	29.6	49.9	-9	32
	1979[4]	25.2	13.0	9.3	2.9	113.4	32.7	30.0	50.7	-9	32
	1980[3]	21.7	12.6	6.9	2.3	108.2	30.4	27.6	50.2	-14	-3
	1980[4]	21.8	12.7	6.9	2.3	109.8	30.9	28.0	51.0	-13	-3
	1981[3]	27.8	15.3	5.9	6.5	118.3	29.8	29.4	58.8	28	9
	1982[3]	25.2	14.8	7.7	2.7	90.2	22.2	28.2	39.8	-9	-24
	1983[3]	23.6	12.0	3.8	7.8	165.8	50.9	52.8	62.0	-8	84
31	Leather and leather products										
	1973	4.3	1.8	1.9	.6	6.1	.9	3.0	2.3	X	X
	1974	3.2	D	1.8	D	8.1	1.0	4.2	2.9	-26	33
	1975	7.0	D	5.1	D	9.3	1.2	4.9	3.2	119	15
	1976	17.4	7.3	9.6	.5	11.0	1.1	6.7	3.3	149	18
	1977[3]	11.4	1.8	9.3	.4	15.4	1.1	9.1	5.2	-34	40
	1977[4]	11.5	1.8	9.4	.4	15.7	1.1	9.3	5.3	-34	43
	1978[3]	S	S	S	S	19.3	1.4	11.3	6.6	X	25
	1978[4]	S	S	S	S	19.7	1.4	11.5	6.7	X	25
	1979[3]	D	D	D	D	22.5	1.3	14.6	6.6	X	16
	1979[4]	D	D	D	D	22.9	1.3	14.9	6.7	X	16
	1980[3]	S	S	S	S	26.3	1.1	14.4	10.7	X	17
	1980[4]	S	S	S	S	26.8	1.1	14.8	10.9	X	17
	1981[3]	D	D	D	D	S	S	S	S	X	X
	1982[3]	2.0	.7	.9	.3	15.5	.8	9.9	4.8	X	X

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Pollution Abatement Expenditures, by Selected Industry, 1973-1983—Continued
(million dollars)

SIC code[1]	Industry and year	Capital expenditures (PACE) Total	Air	Water	Solid waste	Gross annual costs (GAC), including payments to government units Total	Air	Water	Solid waste	Percent change[2] in totals PACE	GAC
	1983[3]	S	S	S	S	21.6	1.5	11.6	8.5	X	40
32	Stone, clay, glass products										
	1973	150.7	131.6	14.4	4.7	117.0	73.7	16.4	27.0	X	X
	1974	208.8	185.8	13.1	10.0	152.9	98.7	24.7	29.4	39	31
	1975	173.5	152.7	16.7	4.1	171.8	109.7	28.3	33.8	-17	12
	1976	104.7	82.2	18.9	3.6	192.1	122.8	30.3	39.0	-40	12
	1977[3]	133.4	85.8	39.1	8.6	214.5	141.7	28.0	44.5	27	12
	1977[4]	136.9	88.0	40.1	8.8	218.4	144.3	28.5	45.3	31	14
	1978[3]	123.8	92.1	28.0	3.7	251.1	163.7	33.2	54.2	-7	17
	1978[4]	127.0	94.5	28.7	3.8	255.6	166.6	33.8	55.2	-7	17
	1979[3]	145.6	110.2	25.4	10.0	293.6	188.0	45.1	60.5	18	17
	1979[4]	149.4	113.1	26.1	10.3	298.9	191.4	45.9	61.6	18	17
	1980[3]	151.0	123.1	17.9	10.0	301.7	182.1	48.2	71.4	4	3
	1980[4]	154.9	126.3	18.4	10.3	307.1	185.4	49.1	72.7	4	3
	1981[3]	188.5	165.6	13.8	9.2	310.7	191.0	47.3	72.5	25	3
	1982[3]	105.2	84.9	14.0	6.3	260.2	142.8	44.0	72.8	-44	-16
	1983[3]	95.9	57.9	9.8	28.2	320.4	179.9	55.8	84.6	-9	23
33	Primary metal industries										
	1973	498.6	397.2	84.7	16.8	466.8	264.7	148.3	53.8	X	X
	1974	646.8	501.5	132.7	12.5	590.2	339.6	181.2	69.5	30	26
	1975	833.5	640.6	187.5	5.4	715.2	429.9	209.4	75.9	29	21
	1976	833.7	632.5	197.8	3.3	895.8	575.7	229.5	90.7	-	25
	1977[3]	874.6	616.0	250.2	8.4	1,122.3	721.6	268.3	132.3	5	25
	1977[4]	876.4	617.2	250.7	8.4	1,122.6	721.8	268.4	132.4	5	25

Pollution Abatement Expenditures, by Selected Industry, 1973–1983—Continued

(million dollars)

Table A-20

Pollution abatement and control expenditures

SIC code[1]	Industry and year	Capital expenditures (PACE)			Solid waste	Gross annual costs (GAC), including payments to government units			Solid waste	Percent change[2] in totals	
		Total	Air	Water		Total	Air	Water		PACE	GAC
	1978[3]	791.8	563.3	219.1	9.4	1,321.4	809.6	333.0	178.9	-9	18
	1978[4]	793.4	564.4	219.5	9.4	1,321.8	809.9	333.1	179.0	-9	18
	1979[3]	823.1	588.8	227.3	6.9	1,587.2	981.7	442.0	163.5	4	20
	1979[4]	824.7	590.0	227.7	6.9	1,587.7	982.0	442.1	163.6	4	20
	1980[3]	740.0	539.7	180.7	19.6	1,676.8	998.2	463.2	215.3	-10	6
	1980[4]	741.5	540.8	181.1	19.6	1,677.3	998.5	463.3	215.5	-10	6
	1981[3]	728.2	567.2	144.1	16.9	1,911.8	1,111.9	549.2	250.7	-2	14
	1982	569.8	423.1	133.7	13.0	1,513.6	897.2	448.4	167.6	-22	-21
	1983	255.3	147.6	100.2	7.5	1,615.6	904.3	454.6	256.7	-55	7
34	Fabricated metal products										
	1973	63.7	39.6	21.5	2.7	84.8	27.0	35.7	22.2	X	X
	1974	90.5	56.4	28.2	5.9	110.1	34.5	44.9	30.7	42	30
	1975	77.5	46.9	29.0	1.7	109.5	32.6	45.7	31.3	-14	-1
	1976	72.9	35.5	34.1	3.4	124.3	35.4	52.7	36.1	-6	14
	1977[3]	76.7	32.5	39.2	5.0	149.2	40.3	66.1	42.8	5	20
	1977[4]	76.9	32.6	39.3	5.0	150.8	40.7	66.8	43.3	5	21
	1978[3]	61.6	33.1	26.2	2.3	168.7	42.1	73.8	52.8	-20	13
	1978[4]	61.8	33.2	26.3	2.3	170.6	42.6	74.6	53.4	-20	13
	1979[3]	66.1	36.7	24.5	4.9	220.9	57.0	99.7	64.2	7	31
	1979[4]	66.3	36.8	24.6	4.9	223.3	57.6	100.8	64.9	7	31
	1980[3]	76.4	37.5	34.8	4.2	219.2	49.0	88.2	81.9	16	-1
	1980[4]	76.5	37.6	34.9	4.2	221.6	49.5	89.3	82.8	16	-1
	1981[3]	75.7	37.4	30.4	7.6	230.5	51.6	93.4	85.0	-1	5
	1982	83.5	33.5	43.3	6.7	223.5	48.6	103.4	71.5	10	-3

Pollution Abatement Expenditures, by Selected Industry, 1973–1983—Continued **Table A-20**
(million dollars) **Pollution abatement and control expenditures**

SIC code[1]	Industry and year	Capital expenditures (PACE) Total	Air	Water	Solid waste	Gross annual costs (GAC), including payments to government units Total	Air	Water	Solid waste	Percent change[2] in totals PACE	GAC
	1983	70.6	27.0	32.9	10.6	366.3	81.9	137.8	146.6	-16	64
35	Machinery, except electrical										
	1973	56.3	36.6	15.6	4.1	72.5	19.7	23.0	29.9	X	X
	1974	67.7	41.9	17.6	8.1	91.7	24.3	29.1	38.2	20	26
	1975	60.5	37.5	20.8	2.3	98.0	28.4	33.7	36.0	-11	7
	1976	69.4	44.8	21.8	2.9	117.9	30.8	37.7	49.6	15	20
	1977[3]	90.2	42.3	42.4	5.5	135.4	33.1	49.8	52.6	30	15
	1977[4]	90.2	42.3	42.4	5.5	138.5	33.9	50.9	53.8	30	17
	1978[3]	81.5	41.4	27.8	12.6	158.8	41.0	54.4	63.1	-10	17
	1978[4]	81.5	41.4	27.8	12.6	162.5	42.0	55.7	64.6	-10	17
	1979[3]	84.5	38.5	38.2	7.8	200.2	50.1	69.0	81.1	4	26
	1979[4]	84.5	38.5	38.2	7.8	204.8	51.2	70.6	83.0	4	26
	1980[3]	74.5	34.0	34.9	5.6	206.4	48.0	73.0	85.3	-12	3
	1980[4]	74.5	34.0	34.9	5.6	211.1	49.1	74.7	87.3	-12	3
	1981[3]	67.1	30.9	28.0	8.2	220.9	47.3	81.6	91.7	-10	7
	1982	78.2	29.2	42.2	6.8	207.6	46.6	85.3	75.7	17	-6
	1983	51.0	17.7	19.0	14.3	290.5	58.0	105.0	127.5	-35	40
36	Electric, electronic equipment										
	1973	52.7	27.0	22.2	3.5	87.2	20.2	38.9	28.1	X	X
	1974	55.6	24.6	28.0	3.1	88.6	22.7	39.8	26.2	6	2
	1975	52.3	22.7	26.2	3.3	97.3	27.6	43.1	26.7	-6	10
	1976	58.4	23.0	31.3	4.1	109.9	26.8	50.8	32.3	12	13
	1977[3]	63.8	23.0	36.0	4.9	128.1	28.0	63.2	37.1	9	17
	1977[4]	66.4	23.9	37.5	5.1	128.2	28.0	63.3	37.1	14	17

P00000123651

Pollution Abatement Expenditures, by Selected Industry, 1973-1983—Continued
(million dollars)

Table A-20
Pollution abatement and control expenditures

SIC code[1]	Industry and year	Capital expenditures (PACE) Total	Capital expenditures (PACE) Air	Capital expenditures (PACE) Water	Solid waste	Gross annual costs (GAC), including payments to government units Total	GAC Air	GAC Water	Solid waste	Percent change[2] in totals PACE	Percent change[2] in totals GAC
	1978[3]	72.2	32.9	36.0	3.3	148.6	30.7	71.7	46.1	13	16
	1978[4]	75.2	34.3	37.5	3.4	148.7	30.7	71.7	46.1	13	16
	1979[3]	90.9	41.8	42.0	7.1	182.3	46.7	82.8	52.8	26	23
	1979[4]	94.6	43.5	43.7	7.2	182.4	46.7	82.8	52.8	26	23
	1980[3]	79.0	43.5	27.1	8.4	205.0	45.2	87.8	71.9	-13	12
	1980[4]	82.2	45.3	28.2	8.7	205.2	45.3	87.9	72.0	-13	13
	1981[3]	97.1	48.7	41.0	7.4	247.1	51.8	106.2	88.8	23	21
	1982	105.9	58.1	40.9	6.9	260.2	55.1	116.6	88.7	9	5
	1983	97.0	43.8	45.1	8.0	353.8	77.3	142.0	134.5	-8	36
37	Transportation equipment										
	1973	101.2	52.6	41.7	6.9	129.8	35.2	51.1	43.4	X	X
	1974	103.4	52.7	41.5	9.2	154.8	44.8	59.5	50.5	2	19
	1975	75.4	32.1	36.4	6.8	168.3	52.2	66.4	49.7	-27	9
	1976	78.5	21.1	53.6	3.8	197.9	56.9	83.5	57.6	4	18
	1977[3]	82.6	36.9	39.4	6.3	233.9	60.6	97.3	76.1	5	18
	1977[4]	82.6	36.9	39.4	6.3	233.9	60.6	97.3	76.1	5	18
	1978[3]	139.5	71.0	57.9	10.7	280.5	77.3	110.2	93.0	69	20
	1978[4]	139.5	71.0	57.9	10.7	280.5	77.3	110.2	93.0	69	20
	1979[3]	189.5	120.1	59.5	9.9	331.8	96.4	126.3	109.1	36	18
	1979[4]	189.5	120.1	59.5	9.9	331.8	96.4	126.3	109.1	36	18
	1980[3]	275.0	201.4	60.7	12.9	401.5	110.7	137.4	153.2	45	21
	1980[4]	275.0	201.4	60.5	12.9	401.5	110.7	137.4	153.2	45	21
	1981[3]	283.3	209.2	60.0	14.2	426.1	117.5	150.7	157.7	3	6
	1982	108.3	59.7	36.5	12.1	396.5	105.6	153.5	137.6	-62	-7

P00000123652

Pollution Abatement Expenditures, by Selected Industry, 1973–1983—Continued

(million dollars)

SIC code[1]	Industry and year	Capital expenditures (PACE)			Solid waste	Gross annual costs (GAC), including payments to government units			Solid waste	Percent change[2] in totals	
		Total	Air	Water		Total	Air	Water		PACE	GAC
	1983	98.3	33.0	55.0	10.2	560.3	157.5	224.2	178.6	-9	41
38	Instruments, related products										
	1973	11.8	3.0	5.6	3.2	21.9	2.0	11.3	8.6	X	X
	1974	15.7	3.6	6.7	5.5	34.1	4.9	15.0	14.3	33	56
	1975	29.6	11.2	17.3	1.1	38.5	5.9	19.5	13.2	89	13
	1976	32.3	10.9	12.2	9.3	45.7	8.7	22.3	14.8	9	19
	1977[3]	24.4	14.5	8.5	1.4	47.3	9.0	23.0	15.4	-24	4
	1977[4]	25.5	15.1	8.9	1.5	47.6	9.1	23.1	15.5	-21	4
	1978[3]	16.9	6.8	9.5	.6	55.8	7.3	26.9	21.6	-31	18
	1978[4]	17.7	7.1	9.9	.6	56.2	7.4	27.1	21.8	-31	18
	1979[3]	23.2	13.0	7.7	2.5	69.2	10.6	30.7	27.9	37	23
	1979[4]	24.2	13.6	8.0	2.6	69.7	10.7	30.9	28.1	37	23
	1980[3]	27.2	11.3	12.7	3.2	77.1	11.3	33.7	32.1	17	11
	1980[4]	28.4	11.8	13.3	3.3	77.6	11.4	33.9	32.3	17	11
	1981[3]	40.1	14.4	23.7	2.1	90.4	12.8	40.0	37.9	47	17
	1982	30.0	18.7	9.8	1.4	80.2	12.9	33.9	33.3	-25	-11
	1983	21.2	10.4	9.5	1.2	163.8	25.0	53.9	85.0	-30	104
39	Miscellaneous manufacturing industries										
	1973	12.1	5.3	4.8	2.0	15.2	6.0	3.9	5.4	X	X
	1974	14.1	7.3	5.8	1.0	20.7	7.3	5.6	7.8	17	36
	1975	5.6	2.3	1.7	1.5	18.2	5.7	5.5	7.0	-60	-12
	1976	4.9	3.3	1.4	.2	22.4	7.8	6.3	8.3	-13	23
	1977[3]	6.6	2.5	3.9	.3	19.0	5.3	5.2	8.4	35	-15

P00000123653

Pollution Abatement Expenditures, by Selected Industry, 1973-1983—Continued
(million dollars)

Table A-20
Pollution abatement and control expenditures

SIC code[1]	Industry and year	Capital expenditures (PACE) Total	Air	Water	Solid waste	Gross annual costs (GAC), including payments to government units Total	Air	Water	Solid waste	Percent change[2] in totals PACE	GAC
	1977[4]	6.6	2.5	3.9	.3	19.0	5.3	5.2	8.4	35	-15
	1978[3]	S	S	S	S	22.1	4.0	5.8	12.3	X	16
	1978[4]	S	S	S	S	22.1	4.0	5.8	12.3	X	16
	1979[3]	S	S	S	S	26.3	6.5	7.2	12.6	X	19
	1979[4]	S	S	S	S	26.3	6.5	7.2	12.6	X	19
	1980[3]	11.0	6.4	4.2	.5	26.3	5.2	7.2	13.8	X	–
	1980[4]	11.0	6.4	4.2	.5	26.3	5.2	7.2	13.8	X	–
	1981[3]	11.5	6.7	3.9	.9	28.4	6.2	7.9	14.5	5	8
	1982	4.1	1.5	1.6	.9	26.4	9.5	6.9	10.1	-64	-7
	1983	5.9	3.1	2.1	.7	49.3	12.3	13.0	24.1	44	87

Pollution abatement is the reduction or elimination of pollutants.

Census data are based on a probability sample of 20,000 manufacturing establishments. All establishments which reported shipments in the 1976 Annual Survey of Manufacturers of $30.1 million or more are included, while establishments with less than $30.1 million are selected on a random sample basis. (The Annual Survey of Manufacturers is a probability sample of about 70,000 establishments selected from a total of about 312,000 establishments.) Each establishment is classified into a manufacturing industry based on its primary activity and receives one report form.

Details may not add to totals due to independent rounding.

[1]SIC code: Standard Industrial Classification code.

[2]The calculation of the percentage change is based on the change from the previous year to the subsequent year (that is, 1978 to 1979).

[3]Represents the estimate for establishments with 20 or more employees.

[4]Represents the estimate for all establishments and is comparable to the estimates for 1973 through 1976.

[5]Includes all major industry groups SIC Codes 20-39, with the exception of 23, Apparel and Other Textiles.

D = Data withheld by Census Bureau to avoid disclosing operations of individual companies.

S = Data suppressed by Census Bureau because they did not meet publication standards, for example, if the standard error is 20 or greater.

X = Not applicable.

Sources: U.S. Bureau of the Census, *Pollution Abatement Costs and Expenditures, 1983* (Washington, D.C.: April 1985), and prior annual issues.

Federal and Nonfederal Ownership of U.S. Land, 1955-1982 and by State, 1982
(million acres)

Year	Total	Not owned by Federal Government	Owned by Federal Government[1] Acres	Owned by Federal Government[1] Percent
1955[2]	1,904	1,496	408	21.4
1960	2,273	1,502	772	33.9
1965	2,271	1,506	766	33.5
1970	2,271	1,510	761	33.5
1975	2,271	1,511	760	33.5
1980	2,271	1,552	720[1]	31.7
1982	2,271	1,541	730	32.1
1982, by State				
Alabama	32.678	31.537	1.140	3.492
Alaska[3]	365.028	38.452	327.028	89.479
Arizona	72.688	43.493	29.194	40.164
Arkansas	33.599	30.195	3.404	10.132
California	100.206	52.681	47.525	47.428
Colorado	66.485	42.536	23.949	36.022
Connecticut	3.135	3.125	.009	0.317
Delaware	1.265	1.225	.040	3.214
District of Columbia	.039	.026	.012	31.451
Florida	34.721	31.069	3.651	10.517
Georgia	37.295	35.014	2.282	6.116
Hawaii	4.015	3.318	.786	19.163
Idaho	52.933	18.651	34.281	64.765
Illinois	35.795	35.168	.626	1.750
Indiana	23.158	22.629	.528	2.283

Federal and Nonfederal Ownership of U.S. Land, 1955-1982 and by State, 1982—Continued
(million acres)

Year	Total	Not owned by Federal Government	Owned by Federal Government[1] Acres	Owned by Federal Government[1] Percent
Iowa	35.860	35.632	.228	0.636
Kansas	52.510	51.777	.733	1.396
Kentucky	25.512	24.094	1.417	5.557
Louisiana	28.867	27.710	1.157	4.009
Maine	19.847	19.711	.135	0.685
Maryland	6.319	6.108	.210	3.329
Massachusetts	5.034	4.950	.084	1.684
Michigan	36.492	32.958	3.533	9.683
Minnesota	51.205	47.757	3.448	6.735
Mississippi	30.222	28.473	1.748	5.786
Missouri	44.248	41.994	2.253	5.093
Montana	93.271	65.802	27.468	29.450
Nebraska	49.031	48.335	.696	1.420
Nevada	70.264	12.880	57.383	81.669
New Hampshire	5.768	5.030	.738	12.800
New Jersey	4.813	4.667	.146	3.042
New Mexico	77.766	51.904	25.862	33.256
New York	30.680	30.432	.248	0.811
North Carolina	31.402	29.233	2.169	6.908
North Dakota	44.452	42.206	2.246	5.053
Ohio	26.222	25.870	.351	1.339
Oklahoma	44.087	42.338	1.749	3.967
Oregon	61.598	31.496	30.102	48.869
Pennsylvania	28.804	28.109	.695	2.414

Federal and Nonfederal Ownership of U.S. Land, 1955-1982 and by State, 1982—Continued
(million acres)

Year	Total	Not owned by Federal Government	Owned by Federal Government[1] Acres	Owned by Federal Government[1] Percent
Rhode Island	.677	.670	.006	0.909
South Carolina	19.374	18.180	1.193	6.161
South Dakota	48.881	45.729	3.151	6.448
Tennessee	26.727	24.631	2.095	7.841
Texas	168.217	164.689	3.528	2.097
Utah	52.696	20.530	32.166	61.041
Vermont	5.936	5.617	.319	5.382
Virginia	25.496	23.135	2.360	9.258
Washington	42.693	30.589	12.104	28.352
West Virginia	15.410	14.296	1.113	7.227
Wisconsin	35.011	33.114	1.896	5.418
Wyoming	62.343	31.733	30.610	49.099

Data as of June 30 except for 1980, which is for the fiscal year.
Excludes inland water.
[1]Excludes trust properties.
[2]Excludes Alaska and Hawaii.
[3]Data for Alaska, including inland water, are approximations as of Nov. 1981 and are currently under review. Data are from the Alaska National Interests Lands Conservation Act of December 1980.

Sources:
1955–1975: U.S. Bureau of the Census, *Statistical Abstract of the United States, 1980* (Washington: USGPO, 1981), p. 238.
1980–1982: U.S. Department of the Interior, Bureau of Land Management, *Public Land Statistics, 1983* (Washington, D.C.: 1984), and prior reports.

Federal Ownership of U.S. Land, by Agency, 1982[1]

Table A-22
Land

Agency	Acres	Agency	Acres
Department of Agriculture	192,471,635	Department of Justice	30,140
Forest Service	192,074,751	Department of Labor	3,134
Department of Commerce	55,061	National Aeronautics and Space Administration	134,148
National Oceanic and Atmospheric Administration	51,407	National Science Foundation	3,692
Department of Defense	22,877,838	U.S. Postal Service	6,925
Air Force	637,287	Department of State	120,346
Army	10,568,414	Tennessee Valley Authority	1,010,270
Corps of Engineers	8,544,495	Department of Transportation	184,589
Navy	3,128,641	Federal Aviation Administration	59,766
Department of Energy	2,357,867	Federal Railroad Administration	38,007
Environmental Protection Agency	243	U.S. Coast Guard	81,949
Federal Communications Commission	3,324	Treasury Department	2,476
General Services Administration	14,474	Veterans Administration	25,725
Department of Health and Human Services	5,417	Other federal agencies	376,700
Department of Housing and Urban Development	262	Total Federal	729,820,861
Department of the Interior	510,498,500		
Fish and Wildlife Service	84,907,218		
Geological Survey	1,695		
Bureau of Indian Affairs	3,017,206		
Bureau of Land Management	341,059,245		
Bureau of Mines	13,045		
National Park Service	77,285,815		
Bureau of Reclamation	4,214,244		

Includes changes due to the Alaska National Interests Lands Conservation Act.
[1]Data are for fiscal year 1982.

Source: U.S. Department of the Interior, Bureau of Land Management, *Public Land Statistics, 1983* (Washington, D.C.: 1984), Bureau of Land Management, unpublished data.

Major Uses of Land, 1900–1982
(million acres)

Table A-23
Land

Major land uses	1900	1910	1920	1930	1940	1950	1959	1969	1974	1978	1982
Cropland[1]	319	347	402	413	400	409	392	384	382	395	404
Grassland, pasture, and range[2]	832	778	731	719	719	701	699	692	681	663	662
Forest land[3]	719	721	721	722	727	721	728	723	718	703	655
Other[4]	400	424	416	416	426	442	452	465	483	503	544
Specialized[5]	NA	NA	86	NA	99	136	150	176	182	NA	NA
Unused land[6]	NA	NA	330	NA	327	306	302	289	301	NA	NA
Total U.S. (50 States)[7]	2,270	2,270	2,270	2,270	2,272	2,273	2,271	2,264	2,264	2,264	2,265

NA - Not available

[1]Cropland: Excludes cropland used only for pasture.

[2]Grassland, pasture, and range: Includes grassland pasture, other nonforested grazing land, and cropland used only for pasture. Includes some idle grassland, particularly before 1920.

[3]Forest land: Excludes forest land in parks, wildlife refuges, and other special-use areas.

[4]Other: Includes specialized land and unused land.

[5]Specialized land: Includes urban and built-up areas (including cities and towns, rural highway and road right-of-way, railroads, airports, and public institutions in rural areas) and nonurban special-use areas (including federal and state parks and other rural parks, recreational areas, federal and state wildlife refuges, national defense sites, national defense sites, federal and industrial areas, farmsteads, and farm roads). Data for 1920 and 1940 are estimates based on a proportion using 48 state and 50 state data.

[6]Unused land: Includes miscellaneous uses such as marshes, open bare rock areas, deserts, tundra, and other uses not inventoried. Data for 1920 and 1940 are estimated by subtracting specialized from other and are based on a proportion using 48 and 50 State data.

[7]Changes in total land area are attributable to changes in methods and materials used in occasional remeasurements and to increases in the area of artificial reservoirs. The U.S. Department of Agriculture estimated data for 1900–1959 assume essentially no change in Alaska and Hawaii prior to 1950. The estimates are not strictly comparable.

Sources:

1900, 1920, 1940–1974 (except specialized, 1920 and 1940): U.S. Department of Agriculture, Economics, Statistics, and Cooperatives Service, *Major Uses of Land in the United States: 1974* (Washington: USGPO, 1979), Table 3, p.4.

Specialized, 1920 and 1940: U.S. Department of Agriculture, Economic Research Service, Major Uses of Land and Water in the United States, Summary for 1959, Agricultural Economic Report No. 13, p.11.

1910, 1930: U.S. Department of Agriculture, Economics, Statistics, and Cooperatives Service, unpublished data.

1978–1982: U.S. Department of Agriculture, Economic Research Service, AER No. 535, *Major Use of Land in the United States; 1985* (Washington, D.C.: June 1985), and prior reports.

Special Uses of Land, United States, 1949–1982
(million acres)

Land use	1949	1959	1969	1978	1982	Land use	1949	1959	1969	1978	1982
*Urban areas[1]	18.3	27.2	34.6	NA	47.3[8]	National defense and industrial[5]	25.7	26.3	25.6	24.9	24.0
Farmsteads, farm roads[2]	10.3	10.1	8.4	8.4	8.0	Parks and wilderness areas[6]	40.4	44.2	49.3	56.7	115.6[9]
Roadways[3]	19.4	20.5	21.0	21.5	21.5	Wildlife areas[7]	16.7	17.2	32.0	41.4	95.2[9]
Railroads, airports[4]	4.8	4.8	5.0	5.2	5.3	Total	135.6	150.3	175.9	NA	316.9

NA - Not available.

[1]Urbanized areas and other incorported and unincorporated places of 1,000 population or more. Estimates are based on area data for urban areas developed in conjunction with the 1950, 1960, and 1970 Censuses of Population but differ in that (1) Census reported areas were adjusted to minimize the inclusion of vacant land and (2) places of 1,000–2,500 population (classified by the Bureau of the Census as rural) are included.

[2]Estimates for farmsteads, farm roads, and farm lanes calculated on the basis of State-by-State number of farms and acreage of unclassified land in farms.

[3]Estimates for rural highways and roads derived by applying average right-of-way widths to the mileage in different highway systems reported by the Federal Highway Administration.

[4]Estimates for rural railroads derived by applying average right-of-way widths to the mileage reported by the Interstate Commerce Commission and Association of American Railroads. Estimates of rural airports based on information on active airports supplied by the Federal Aviation Administration. Excludes airports used strictly for personal or military use.

[5]Land administered by the Department of Defense for defense purposes and land administered by the Department of Energy, as reported by the Bureau of Land Management.

[6]Area in national and State park systems and national forest wilderness and primitive areas. Generally excludes parks in urban places and large water bodies. Based on data from reports and records of the National Park Service, Forest Service, and State agencies.

[7]Areas administered by the U.S. Fish and Wildlife Service and State wildlife agencies. Does not include federal areas under the primary jurisdiction of another agency or leased for wildlife purposes. Data on federal areas are from reports and records of the U.S. Fish and Wildlife Service. State acreages are based on data from individual state agencies, occasional surveys by various federal agencies and commissions, and reports on acreage acquired with federal assistance through the Dingell-Johnson and Pittman-Robertson programs.

[8]Based on 1980 census data.

[9]Reflects changes in Alaskan land classifications.

Sources:

1959–1974: U.S. Department of Agriculture, Economic Research Service, *Major Uses of Land and Water in the United States, Summary for 1959,* Agricultural Economic Report No. 13, p. 10; *Summary for 1969* (Washington: USGPO, 1973), p. 17; Economics, Statistics, and Cooperatives Service, *Major Uses of Land in the United States: 1974* (Washington: USGPO, 1979) Tables 3, 11, 12; pp. 4, 18, 21.

1978: U.S. Department of Agriculture, Economics, Statistics, and Cooperatives Service, unpublished data.

1982: U.S. Department of Agriculture, Economic Research Service, *Major Uses of Land in the United States: 1982* (Washington, D.C: AER No. 535, June 1985).

Uses of Cropland, 1949–1982
(million acres)

Cropland use	1949	'54	'59	'64	'69	'74	'77	'78	'79	'80	'81	'82	'83	'84
Total cropland used for crops[1]	387	380	358	335	333	361	377	369	379	384	390	387	333	370
Harvested	352	339	317	292	286	322	338	330	340	342	353	350	293	334
Crop failure	9	13	10	6	6	8	9	7	7	11	6	7	6	6
Cultivated summer fallow	26	28	31	37	41	31	31	32	32	31	31	30	34	30
Soil improvement and idle cropland	22	19	33	52	51	21	NA	26	NA	NA	NA	20	NA	NA
Cropland pasture	69	66	66	57	88	83	NA	76	NA	NA	NA	67	NA	NA
Total cropland	478	465	457	444	472	465	NA	471	NA	NA	NA	474	NA	NA
Diverted acres[2]	0	0	22	55	57	0	0	18	12	0	NA	11	76	30

*Preliminary
NA - Not available.
[1]Includes principal and minor crops.
[2]Acreage diverted or set aside to comply with Federal Farm Supply Management Programs. This acreage is mostly included in the soil improvement and idle cropland category but some is included in the cultivated summer fallow category of cropland.

Sources: U.S. Department of Agriculture, Economic Research Service, U.S. Department of Agriculture, *Our Land and Water Resources* (Washington: 1974), Misc. Pub. No. 1290, p. 4; Economics, Statistics, and Cooperatives Service, *Major Uses of Land in the United States: 1974* (Washington: USGPO, 1979), pp. 3, 6; 1978: *Major Uses of Land in the United States: 1978*, AER #487, U.S. Department of Agriculture, Economic Research Service, unpublished data; 1979, 1980, 1981, 1982, 1983, 1984: USDA, Economic Research Service, unpublished data.

Erosion on Nonfederal Land in the United States, by Land Use, 1982

Land Cover/Use[1]	Total Non-Federal Acreage in Use in 1982 (Million Acres)	Estimated Average Annual Total Erosion, 1982 (Tons/Acre)[2]	Estimated Average Annual Sheet and Rill Erosion, 1982 (Tons/Acre)[2]	Estimated Average Annual Wind Erosion, 1982 (Tons/Acre)[2]
Cropland (All)	421.4	7.4	4.4	3.0
Cropland (Cultivated)	376.5	8.1	4.8	3.3
Pastureland	133.3	1.4	1.4	0.0
Rangeland	405.9	2.9	1.4	1.5
Forest Land (All)	393.7	1.0	0.9	0.1
Forest Land (Grazed)	66.1	2.3	2.3	0.0
Forest Land (Not Grazed)	327.6	0.7	0.7	0.0
	1,354.3[3]			

[1]All data in this table excludes Alaska.
[2]Total erosion, 1982 includes Sheet, Rill and Wind erosion for all States.
[3]Total non-Federal cropland, pastureland, rangeland and forest land.

Source: U.S. Department of Agriculture, Soil Conservation Service

Erosion on Nonfederal Cropland, by State, 1982

State	Total erosion (1,000 tons)	Erosion rate (tons/acre)	State	Total erosion (1,000 tons)	Erosion rate (tons/acre)
Alabama	32,183.1	7.1	New Jersey	4,673.1	5.8
Alaska	NA		New Mexico	15,711.6	6.5
Arizona	4,523.9	3.8	New York	17,413.3	3.0
Arkansas	39,718.4	4.9	North Carolina	45,667.2	6.8
California	23,345.2	2.2	North Dakota	136,185.3	5.0
Colorado	121,626.8	11.5	Ohio	49,382.8	4.0
Connecticut	694.0	2.8	Oklahoma	63,706.5	5.5
Delaware	1,982.5	3.8	Oregon	24,665.1	5.7
District of Columia	NA	NA	Pennsylvania	31,171.1	5.3
Florida	10,519.9	3.0	Rhode Island	66.7	2.5
Georgia	41,713.7	6.4	South Carolina	12,931.6	3.6
Hawaii	2,115.0	6.4	South Dakota	89,581.6	5.3
Idaho	50,570.0	7.9	Tennessee	55,896.4	10.0
Illinois	172,432.0	7.0	Texas	525,384.1	15.8
Indiana	84,670.6	6.1	Utah	6,718.8	3.3
Iowa	318,000.6	12.0	Vermont	831.1	1.3
Kansas	160,033.9	5.5	Virginia	21,642.3	6.4
Kentucky	56,537.3	9.5	Washington	53,663.4	6.9
Louisiana	29,310.2	4.6	West Virginia	2,810.0	2.6
Maine	1,988.6	2.1	Wisconsin	67,405.2	5.9
Maryland	9,223.6	5.2	Wyoming	4,463.2	1.7
Massachusetts	620.8	2.1			

Erosion on Nonfederal Cropland, by State, 1982—Continued

State	Total erosion (1,000 tons)	Erosion rate (tons/acre)	State	Total erosion (1,000 tons)	Erosion rate (tons/acre)
Michigan	36,292.4	c3.8	Total U.S.	3,087,849.5	NA
Minnesota	147,760.2	6.4	Caribbean	4,694.7	11.5
Mississippi	55,268.1	7.5			
Missouri	146,452.9	9.8	Grand Total	3,092,544.2	NA
Montana	169,951.2	9.9			
Nebraska	132,072.3	6.5			
Nevada	7,980.8	9.3			
New Hampshire	191.1	1.2			

NA - Not available.
This information is being updated by the Soil Conservation Service.

Source: U.S. Department of Agriculture, *1980 Appraisal, Part 1, Soil, Water, and Related Resources in the United States: Status, Condition, and Trends* (Washington: USGPO, 1982), Table 42, pp. 159–160.

Forest Conditions, 1950–1983

Year	Area planted and direct seeded[1] (1,000 acres)	Wildfires: Number of fires (1,000)	Wildfires: Area burned (1,000 acres)	Gypsy moth infestation (1,000 acres defoliated)	Spruce budworm infestation (1,000 acres defoliated): Total United States	Western United States[3]	Eastern United States[3]
1950	488	208	15,519	5	5,601	2,041	3,560
1951	453	164	10,781	21	3,388	3,151	237
1952	520	188	14,187	293	4,395	3,979	416
1953	710	154	9,976	1,487	3,756	3,736	20
1954	808	177	8,833	491	4,507	4,504	3
1955	779	145	8,069	52	6,016	6,016	NA
1956	886	143	6,606	43	NA	NA	NA
1957	1,138	83	3,410	6	7,383	4,434	2,949
1958	1,533	98	3,280	0.13	8,509	4,209	4,300
1959	2,117[2]	105	4,156	14	6,644	4,704	1,940
1960	2,100	103	4,478	49	5,018	5,018	NA
1961	1,761	99	3,036	67	7,659	6,539	1,120
1962	1,366	115	4,079	308	8,740	7,670	1,070
1963	1,325	164	7,121	173	3,443	2,884	559
1964	1,313	116	4,197	255	5,009	5,009	NA
1965	1,285	114	2,652	263	4,461	4,461	NA
1966	1,281	123	4,574	52	NA	NA	NA
1967	1,373	125	4,659	52	NA	NA	NA

Forest Conditions, 1950-1983—Continued

Table A-28
Land

Year	Area planted and direct seeded[1] (1,000 acres)	Wildfires: Number of fires (1,000)	Wildfires: Area burned (1,000 acres)	Gypsy moth infestation (1,000 acres defoliated)	Spruce budworm infestation (1,000 acres defoliated): Total United States	Western United States[3]	Eastern United States[3]
1968	1,439	125	4,232	80	6,598	5,344	1,254
1969	1,431	113	6,689	256	5,784	4,572	1,212
1970	1,600	122	3,279	973	5,989	4,012	1,977
1971	1,693	108	4,278	1,945	6,456	4,838	1,618
1972	1,680	125	2,641	1,369	8,255	5,477	2,778
1973	1,750	118	1,915	1,774	8,652	4,441	4,211
1974	1,603	146	2,879	751	16,242	5,468	10,774
1975	1,930	135	1,791	464	14,501	5,282	9,219
1976	1,892	242	5,110	865	14,976	5,838	9,138
1977	1,978	174	3,153	1,595	16,986	6,732	10,254
1978	2,089	219	3,911	1,259	12,864	5,198	7,666
1979	2,061	163	3,034	644	11,633	5,011	6,622
1980	2,267	235	5,261	5,105	10,680	4,078	6,602
1981	1,926	165	2,953	12,873	9,422	4,931	4,491
1982	2,375	174	2,382	8,172	12,976	8,681	4,295
1983	NA	NA	NA	2,383	17,486	10,998	6,488

NA - Not available.
[1]Data on seeding include forest plantings, wind barrier plantings, and direct seedings.
[2]The increase in plantings and seedings in the 1950s was due to the Soil Bank Program which peaked in 1959.

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[3]Spruce budworm infestation in the western United States affects areas west of the Great Plains, primarily Arizona, Colorado, Idaho, Montana, New Mexico, Oregon, Utah, Washington, and Wyoming. In the eastern United States, it primarily affects Maine, Michigan, Minnesota, New Hampshire, New York, Vermont, and Wisconsin.

Sources:

Areas planted and direct seeded: 1950–1969: U.S. Department of Agriculture, Forest Service, *The Outlook or Timber in the United States* (Washington: USGPO, 1974), p. 40; 1970–1979: U.S. Department of Agriculture, Forest Service, *1979 Report, Forest Planning, Seeding, and Silvical Treatments in the United States* (Washington: USGPO, 1980), p. 1, and previous annual issues; 1981: U.S. Forest Service, Cooperative Forestry Staff, unpublished data; 1982: "1982 U.S. Forest Planning Report," U.S. Department of Agriculture, Forest Service (Washington, D.C., July 1983);

Wildfires: 1950–1959: U.S. Bureau of the Census, *Historical Statistics of the United States, Colonial Times to 1970* (Washington: USGPO, 1975), p. 537; 1960–1978: U.S. Department of Agriculture, Forest Service, *1978 Wildfire Statistics* (Washington: USGPO, 1980), p. 18, and previous annual issues; 1979–1981: U.S. Department of Agriclulture, Forest Service, Cooperative Fire Protection Staff, unpublished data.

Gypsy moth infestation: U.S. Department of Agriculture, Cooperative Gypsy Moth Suppression and Regulatory Program, *Final Programmatic Environmental Impact Statement,* FS-FEIS 81-01, February 27, 1981; *1953–1983*: U.S. Department of Agriculture, Forest Service, *Forest Insect and Disease Conditions in the United States, 1983* (Washington: USGPO, 1984), and previous annual reports.

Spruce budworm infestation: 1950–1952: U.S. Department of Agriculture, Agricultural Research Administration, Bureau of Entomology, *The Most Important Forest Insects in 1952—A Summary* (Washington: USGPO, 1953); *1953–1983*: U.S. Department of Agriculture, Forest Service, *Forest Insect and Disease Conditions in the United States, 1983* (Washington: USGPO, 1984), and previous annual reports.

Recreational Use of the National Forests, 1965–1984
(million visitor-days)[1]

Table A-29
Land

Calendar Year	Campgrounds	Winter sports sites	Other Special use	Other developed sites	Wilderness system	Other dispersed	Total
1965	34.0	5.5	19.9	9.4	4.5	84.4	157.7
1966	32.7	4.8	18.2	8.2	4.8	82.1	150.7
1967	30.2	5.1	17.7	7.9	4.7	84.1	149.6
1968	30.7	5.6	18.5	7.7	5.1	89.1	156.7
1969	31.7	5.7	18.2	8.2	5.1	94.0	162.8
1970	34.6	6.5	17.7	8.9	5.8	99.1	172.6
1971	35.7	7.0	17.6	9.4	8.1	100.3	178.1
1972	36.1	6.5	17.4	9.6	6.5	107.9	184.0
1973	36.0	8.3	16.7	9.8	6.7	110.8	188.2
1974	35.7	7.7	17.1	9.5	6.7	116.2	192.9
1975	37.7	8.9	17.6	10.8	7.8	116.3	199.2
1976	37.1	7.1	17.4	11.5	7.1	119.7	199.9
1977	37.5	7.0	16.9	12.3	8.0	123.0	204.8
1978	39.6	10.6	16.7	12.7	8.6	130.2	218.5
1979	39.1	12.8	17.2	12.7	9.6	128.7	220.2
1980	40.3	13.5	17.4	14.3	9.3	138.7	233.5
1981	41.2	10.6	17.1	16.0	11.4	139.4	235.7
1982	38.8	13.4	17.3	14.9	11.2	138.0	233.4
1983	35.7	13.7	17.0	14.6	9.9	136.8	227.7
1984	36.2	13.9	16.8	15.4	10.2	135.1	227.6

[1]Visitor-day equals recreational use of National Forest land and water that aggregates to 12 person-hours. It may entail 1 person for 12 hours, 12 persons for 1 hour, or any equivalent combination of individual or groups use, either continuous or intermittent.

Source: U.S. Department of Agriculture, Forest Service, Recreation Information Management System, unpublished data, 1984.

Properties[1] on the National Register of Historic Places, 1968–1984

Table A-30
Land

Year	Annual addition	Cumulative total	Year	Annual addition	Cumulative total
1968	6	6	1976	2,057	12,113
1969	359	365	1977	1,516	13,629
1970	832	1,197	1978	3,158	16,787
1971	1,026	2,223	1979	2,783	19,570
1972	1,533	3,756	1980	2,905	22,475
1973	2,162	5,918	1981	504	22,979
1974	2,151	8,069	1982	3,136	26,115
1975	1,987	10,056	1983	4,493	30,608
			1984[2]	3,804	34,412

The National Register of Historic Places lists buildings, districts, sites, objects, and structures of historic interest. While registration does not guarantee protection, it does bring historically important properties to public attention, thereby increasing the likelihood that they will be preserved or restored and used.

[1]Does not include 1,616 National Historic Landmarks.

Source: U.S. Department of the Interior, National Park Service, National Register of Historic Places, unpublished data.

Comparative Percentages of the Public Rangelands in Excellent, Good, Fair, and Poor Condition, 1936–1984

Table A-31
Land

Year	Excellent	Percent by Condition Class: Good	Fair	Poor or Bad
1936	1.5	14.3	47.9	36.3
1966	2.2	16.7	51.6	29.5
1975	2.0	15.0	50.0	33.0
1984[4]	5.0	31.0	42.0	18.0
1984 by State[1]				
Arizona	3	24	52	21
California	1	46	42	11
Colorado[1]	1	16	45	30
Idaho	6	31	46	17
Montanna	5	67	26	2
Nevada	8	25	42	23
New Mexico	2	26	48	24
Oregon	4	25	52	19
Utah[1]	4	33	39	16
Wyoming	6	46	39	8
Bureauwide[2]	5	31	42	18

[1]Totals are less than 100 percent in some States where some lands have not been rated as to range condition.
[2]Aggregation of all baseline resource records maintained at each of the Resource Areas within the BLM. Total acreage = 96%; the remaining four percent has not been rated for range condition.

Sources:
1936: Data adopted from ***The Western Range***, Senate document 199, 75th Congress, 2nd Session.
1966: *The Forage Resources*, Pacific Consultants (1969).
1975: *Range Condition Report*, Department of the Interior (1975).
1984: Department of the Interior, Bureau of Land Management, *50 Years of Public Land Management*(Washington, D.C.: 1985).

National Forest Lands, by State or Other Area, 1983[1]
(million acres)

State	Land within unit boundaries[2]			State or other area	Land within unit boundaries[2]		
	Gross area	National Forest system lands	Other lands		Gross area	National Forest system Lands	Other lands
Alabama	1.274	.645	.630	Minnesota	5.467	2.800	2.667
Alaska	24.018	23.043	.974	Mississippi	2.310	1.144	1.166
Arizona	11.933	11.270	.663				
Arkansas	3.502	2.479	1.023	Missouri	3.082	1.468	1.614
California	24.288	20.435	3.852	Montana	19.087	16.764	2.323
				Nebraska	.442	.352	.090
Colorado	16.014	14.431	1.582	Nevada	5.424	5.150	.275
Connecticut	*	*	0	New Hampshire	.819	.706	.114
Florida	1.225	1.099	.126	New Mexico	10.383	9.348	1.036
Georgia	1.911	.870	1.040	New York	.013	.013	0
Hawaii	*	*	0	North Carolina	3.165	1.216	1.950
				North Dakota	1.106	1.106	*
Idaho	21.703	20.430	1.273	Ohio	.834	.177	.657
Illinois	.840	.262	.578				
Indiana	.645	.188	.457	Oklahoma	.461	.294	.167
Kansas	.116	.108	.008	Oregon	17.456	15.617	1.838
Kentucky	2.103	.673	1.429	Pennsylvania	.743	.511	.232
				South Carolina	1.382	.610	.772
Louisiana	1.023	.598	.425	South Dakota	2.348	1.998	.350
Maine	.094	.051	.042				
Michigan	4.873	2.758	2.116	Tennessee	1.212	.625	.587

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National Forest Lands, by State or Other Area, 1983[1]—Continued
(million acres)

State	Land within unit boundaries[2]: Gross area	National Forest system lands	Other lands	State or other area	Land within unit boundaries[2]: Gross area	National Forest system Lands	Other lands
Texas	1.995	.783	1.212	Wyoming	9.717	9.254	.463
Utah	9.129	8.046	1.083				
Vermont	.630	.294	.336				
Virginia	3.226	1.632	1.593	Puerto Rico	.056	.028	.028
				Virgin Islands	*	*	0
Washington	10.039	9.054	.985				
West Virginia	1.861	.973	.888				
Wisconsin	2.023	1.503	.520	Totals	229.972	190.806	39.164

*Less than 500 acres.
[1]As of September 30, 1983.
[2]Comprises all publicly and privately owned land within authorized boundaries of National Forests, purchase units, National Grasslands, and land utilization projects (research and experimental areas, and other areas).

Source: Department of Agriculture, U.S. Forest Service, *Land Areas of the National Forest System* (Washington, D.C.: 1983).

National Wilderness Preservation System, 1964–1984

Table A-33
Land

Year, agency, and name of area	Number of areas	Acres (millions)
System total		
1964	54	9.14
1980	257	79.83
1982	258	79.84
1983	276	80.51
1984	458	88.54
By agency, 1984		
Forest Service, U.S. Department of Agriculture	328	32.09
National Park Service, U.S. Department of the Interior	37	36.75
Fish and Wildlife Service, U.S. Department of the Interior	70	19.33
Bureau of Land Management, U.S. Department of the Interior	23	.37
By largest areas in system, 1982 (administering agency)		
Wrangell-St. Elias, Alaska (National Park Service)		8.70
Arctic, Alaska (Fish and Wildlife Service)		8.00
Gates of the Arctic, Alaska (National Park Service)		7.05
Noatak, Alaska (National Park Service)		5.80
Katmai, Alaska (National Park Service)		3.47
Glacier Bay, Alaska (National Park Service)		2.77
Lake Clark, Alaska (National Park Service)		2.47
Togiak, Alaska (Fish and Wildlife Service)		2.27
River of No Return, Idaho (Forest Service)		2.23
Misty Fiords, Alaska (Forest Service)		2.14
Denali, Alaska (National Park Service)		1.90
Kenai, Alaska (Fish and Wildlife Service)		1.35
Selway-Bitterroot, Idaho/Montana (Forest Service)		1.34
Aleutian Islands, Alaska (Fish and Wildlife Service)		1.30
Andreafsky, Alaska (Fish and Wildlife Service)		1.30
Everglades, Florida (National Park Service)		1.30
Innoko, Alaska (Fish and Wildlife Service)		1.24
Bob Marshall, Montana (Forest Service)		1.01
Admiralty Island, Alaska (Forest Service)		.94
Absaroka-Beartooth, Montana (Forest Service)		.92

Sources:
1964: U.S. Department of Agriculture, Forest Service, computer printout, August 1, 1977;
1979–1982 total and by agency: U.S. Department of Agriculture, Forest Service, Recreation Management Staff, Wilderness Fact Sheet, December 1, 1983;
1983 by area: U.S. Department of Agriculture and U.S. Department of the Interior, *Twentieth Annual Report to the President on the Status of the National Wilderness Preservation System,* June 13, 1984, unpublished; U.S. Department of the Interior, Fish and Wildlife Service, *National Wilderness Refuge System—Current Status of Wilderness,* updated December 1, 1982, unpublished mimeograph; U.S. Department of Agriculture, Forest Service, Land Areas of the National Forest System, updated April 1985.

National Park System, 1880–1984

Table A–34
Land

Year	Acreage (millions)	Number of areas	No. of areas visited	Visits (millions)	Year	Acreage (millions)	Number of areas	No. of areas visited	Visits (millions)
1880	2.2	5	NA	NA	1966	27.5	228	204	133.1
1890	3.8	12	NA	NA	1967	28.1	230	215	139.7
1900	4.1	17	NA	NA	1968	29.1	238	224	150.8
1910	7.9	45	NA	NA	1969	29.5	245	228	164.0
1920	13.4	64	NA	NA	1970	29.6	249	235	172.0
1930	17.9	106	NA	NA	1971	29.9	252	240	200.5
1940	25.9	153	NA	NA	1972	30.4	264	248	211.6
1950	26.1	172	NA	33.3[1]	1973	30.5	264	259	215.6
1960	26.2	176	176	79.2[1]	1974	31.1	274	266	217.4
1961	26.5	182	180	86.7[1]	1975	31.0	281	259	238.8
1962	26.5	189	183	97.0[1]	1976	31.3	289	264	267.8
1963	26.5	189	184	102.7[1]	1977	31.3	290	265	262.6
1964	26.8	202	194	111.4[2]	1978	76.7[3]	317	269	283.1
1965	27.2	218	199	121.3	1979	76.7	318	271	282.4
					1980	77.0	333	277	300.3
					1981	79.0	333	282	329.6
					1982	79.4	334	296	334.4
					1983	79.4	334	302	335.6
					1984	79.4	334	304	332.5

National Park System, 1980-1984—Continued

Type of Area[4]	Acreage[5]	Number of Areas	Type of Area[4]	Acreage[5]	Number of Areas
National Battlefield	12,249	9	National Parkway	163,225	4
National Battlefield Park	8,169	3	National Preserve	21,106,349	12
National Battlefield Site	1	1	National Recreation Area	3,687,006	17
National Historic Site	17,831	62	National Seashore	597,025	10
National Historical Park	150,789	26	National Rivers	553,963	11
National Lakeshore	224,674	4	National Trails	126,858	1
National Memorial	7,996	24	National Capital Parks	6,467	1
National Military Park	34,551	11	National Mall	146	1
National Monument	4,724,477	77	Parks-Other	32,076	11
National Park	47,971,577	48	White House	18	1
			Total	79,425,452	334

NA - Not available.
Data shown are cumulative totals.
Comparable time-series data for state parks, which are used more intensively than national parks, have not been compiled. The National Recreation and Park Association reported that in 1975 the 3,800 state parks covered 9.8 million acres and received 566 million visits.
[1]Excludes visits to the National Capital Parks.
[2]Excludes visits to the White House.
[3]Increase due to National Monuments in Alaska being designated as National Parks or Preserves.
[4]Not including 26 affiliated areas which do not report public use to the NPS.
[5]Acreage as of December 31, 1982.

Sources:
Acreage and number of areas, 1880-1950: U.S. Department of the Interior, National Park Service, *Index of the National Park System and Affiliated Areas as of January 1, 1975* (Washington: USGPO, 1975). *1960-1982,* By type of area: National Park Service, Land Resources Division, unpublished data.
Visits, 1950: National Park Service, *Public Use of the National Parks: A Statistical Report, 1941-1953* (Washington: USGPO, 1954), p. 1. 1960-1970: National Park Service, *Public Use of the National Parks:* A Statistical Report, 1960-1970 (Washington: USGPO, 1971), p. 5. *1971-1984:* National Park Service Statistical Office, *National Park Statistical Abstract* (Washington, D.C.: 1984), annual issue.

National Wild and Scenic Rivers System, 1968–1984

Table A-35
Land

Year	Annual Addition			Cumulative Total	
	Number of rivers	Miles	Name of river and state	Number of rivers	Miles
1968	8	773	Clearwater, Middle Fork, Idaho Eleven Point, Mo. Feather, Calif. Rio Grande, N. Mex. Rogue, Oreg. St. Croix, Minn./Wis. Salmon, Middle Fork, Idaho Wolf, Wis.	8	773
1969	—	—	—	8	773
1970	1	95	Allagash, Maine	9	868
1971	—	—	—	9	868
1972	1	27	Lower St. Croix, Minn./Wis.	10	895
1973	1	66	Little Miami, Ohio	11	961
1974	1	57	Chattooga, N.C./S.C./Ga.	12	1,018
1975	3	127	Snake, Idaho/Oreg. Rapid, Idaho Little Beaver, Ohio	15	1,145
1976	5	465	New, N.C. Lower St. Croix, Minn./Wis. Missouri, Mont. Flathead, Mont. Obed, Tenn.	19[1]	1,610
1977	—	—	—	19[1]	1,610

National Wild and Scenic Rivers System, 1968–1984—Continued

Table A-35
Land

Year	Annual Addition: Number of rivers	Annual Addition: Miles	Annual Addition: Name of river and state	Cumulative Total: Number of rivers	Cumulative Total: Miles
1978	8	689	Pere Marquette, Mich. Rio Grande, Tex. Skagit, Wash. Upper Delaware, N.Y./Pa. Middle Delaware, N.Y./N.J./Pa. American, North Fork, Calif. Missouri, Nebr./S. Dak. St. Joe, Idaho	25[2]	2,299
1979	—	—	—	25[2]	2,299
1980	27	3,363	Little Miami, Ohio Salmon, Idaho Alagnak, Alatna, Aniakchak, Charley, Chilikadrotna, John, Kobuk, Mulchatna, Noatak, North Fork of the Koyukuk, Salmon, Tinayguk, Tlikakila, Andreafsky, Nowitna, Ivishak, Selawik, Sheenjek, Wind, Beaver Creek, Birch Creek, Delta, Fortymile, Gulkana, Unalakleet, all in Alaska	50[3]	5,662
1981	5	1,246	Klamath, Calif. Trinity, Calif. Eel, Calif. American, Calif. Smith, Calif.	54[4]	6,908
1982	—	—	—	54[4]	6,908

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National Wild and Scenic Rivers System, 1968–1984—Continued

		Annual Addition		Cumulative Total	
Year	Number of rivers	Miles	Name of river and state	Number of rivers	Miles
1983	—	—	—	54	6,908
1984	5	309	Verde, Arizona Tuolumne, Calif. AuSable, Mich. Illinois, Ore. Owyhee, Ore.	59	7,217

To be eligible for inclusion in the National Wild and Scenic Rivers System, a river or river segment must be free flowing, have high water quality, and possess one or more outstanding scenic, recreational, geologic, fish and wildlife, historic, cultural, or similar values. The System is administered by the Departments of the Interior and Agriculture in cooperation with state agencies.

[1]Excludes the Lower St. Croix, which was first admitted to the System in 1968.

[2]Excludes the Rio Grande and Missouri, which were first admitted to the System in 1968 and 1976, respectively.

[3]Excludes the Little Miami and the Salmon in Idaho, which were first admitted to the System in 1973 and 1968, respectively.

[4]Excludes the American, which was first admitted to the System in 1978.

Source: U.S. Department of the Interior, National Park Service, "Summary - Status of the Wild and Scenic Rivers Program," March 3, 1981, unpublished; *1984*, unpublished data.

Water Withdrawn per Day, by State and Puerto Rico, 1980

State or other area	Per capita[1] gallons	Water withdrawn: Total (Billion gallons)	Surface (Billion gallons)	Public supplies (Billion gallons)	Irrigation (Billion gallons)	Fresh water consumed[2] (Million gallons)
Total	1,996	450.4	360	34.0	150.0	100,000
Alabama	2,824	11.0	10	.6	(Z)	570
Alaska	546	(Z)	(Z)	.1	—	35
Arizona	2,929	8.0	4	.6	7.1	4,500
Arkansas	6,960	16.0	12	.3	5.1	3,600
California	2,272	54.0	33	4.1	37.0	25,000
Colorado	5,512	16.0	13	.6	14.0	4,000
Connecticut	1,188	3.7	4	.4	(Z)	160
Delaware	2,013	1.2	1	.1	(Z)	11
District of Columbia	—	(Z)	(Z)	.2	—	23
Florida	2,127	21.0	17	1.4	3.0	2,400
Georgia	1,259	6.9	6	.8	.6	1,000
Hawaii	2,548	2.5	2	.2	1.0	680
Idaho	19,007	18.0	12	.2	10.0	5,900
Illinois	2,187	25.0	17	1.8	.1	590
Indiana	2,551	14.0	13	.6	.2	690

Water Withdrawn per Day, by State and Puerto Rico, 1980—Continued

State or other area	Per capita[1] gallons	Water withdrawn: Total (Billion gallons)	Surface (Billion gallons)	Public supplies (Billion gallons)	Irrigation (Billion gallons)	Fresh water consumed[2] (Million gallons)
Iowa	1,476	4.3	4	.3	.1	290
Kansas	2,788	6.6	1	.3	5.0	4,700
Kentucky	1,311	4.8	5	.4	(Z)	290
Louisiana	3,079	13.0	11	.6	2.2	3,500
Maine	1,421	1.6	2	.1	(Z)	53
Maryland	1,822	7.7	8	.5	(Z)	100
Massachusetts	1,027	5.9	6	.8	(Z)	90
Michigan	1,621	15.0	1	1.3	.2	460
Minnesota	759	3.1	2	.4	.2	450
Mississippi	1,387	3.5	2	.3	1.0	710
Missouri	1,401	6.9	6	.7	.1	670
Montana	13,959	11.0	11	.1	11.0	2,700
Nebraska	7,643	12.0	5	.3	9.3	7,600
Nevada	4,461	3.6	3	.2	3.1	1,700
New Hampshire	1,083	1.0	1	.1	(Z)	17
New Jersey	1,356	10.0	10	1.1	.1	380
New Mexico	2,989	3.9	2	.2	3.0	1,900
New York	967	17.0	16	2.2	(Z)	590

Water Withdrawn per Day, by State and Puerto Rico, 1980—Continued

State or other area	Per capita[1] gallons	Water withdrawn: Total (Billion gallons)	Surface (Billion gallons)	Public supplies (Billion gallons)	Irrigation (Billion gallons)	Fresh water consumed[2] (Million gallons)
North Carolina	1,376	8.1	7	.6	.1	760
North Dakota	1,988	1.3	1	.1	.3	330
Ohio	1,296	14.0	13	1.4	(Z)	550
Oklahoma	592	1.8	1	.3	.9	1,000
Oregon	2,578	6.8	6	.2	5.9	3,200
Pennsylvania	1,347	16.0	15	1.5	.2	920
Rhode Island	527	.1	1	.1	(Z)	15
South Carolina	1,983	6.2	6	.4	.1	280
South Dakota	1,000	.7	(Z)	.1	.5	460
Tennessee	2,176	10.0	10	.5	(Z)	270
Texas	1,466	21.0	13	3.8	8.4	10,000
Utah	3,125	4.6	4	.8	3.2	2,900
Vermont	664	(Z)	(Z)	(Z)	(Z)	41
Virginia	2,238	12.0	9	.5	(Z)	230
Washington	2,001	8.3	8	.8	8.4	2,900
West Virginia	2,872	5.6	5	.2	(Z)	200

Table A-36
Water Resources

Water Withdrawn per Day, by State and Puerto Rico, 1980—Continued

State or other area	Per capita[1] gallons	Water withdrawn: Total (Billion gallons)	Surface (Billion gallons)	Public supplies (Billion gallons)	Irrigation (Billion gallons)	Fresh water consumed[2] (Million gallons)
Wisconsin	1,227	5.8	5	.6	.1	310
Wyoming	11,368	5.4	5	.1	4.9	2,600
Puerto Rico[3]	980	3.2	3	.4	.3	300

Figures may not add due to rounding.
Withdrawal signifies water physically withdrawn from a source. Includes fresh and saline water; excludes water used for hydroelectric power.
Z = Less than 500 million.
[1]Based on population as of July 1.
[2]Evaporated transpired, or incorporated into products; excludes irrigation conveyance losses by evapotranspiration.
[3]Includes Virgin Islands

Source: Department of the Interior, U.S. Geological Survey, *Estimated Use of Water in the United States in 1978,* Geological Survey Circular 1001 (Washington, D.C.: 1983), and previous quinquennial issues.

U.S. Water Withdrawals and Consumption, by End Use and Per Capita, 1900–1980

Year	Total (billion gal/day)	Total Per capita[1] (gal/day)	Irrigation (billion gal/day)	Public water utilities (billion gal/day)	Public water utilities Per capita[1] (gal/day)	Rural domestic (billion gal/day)	Industrial and miscellaneous (billion gal/day)	Steam electric utilities (billion gal/day)
Withdrawals								
1900	40	526	20	3	39	2.0	10	5
1910	66	714	39	5	54	2.2	14	6
1920	92	864	56	6	56	2.4	18	9
1930	110	894	60	8	65	2.9	21	18
1940	136	1,027	71	10	75	3.1	29	23
1950	200	1,317	110	14	92	3.6	37	40
1955	240	1,454	110	17	103	3.6	39	72
1960	270	1,500	110	21	117	3.6	38	100
1965	310	1,602	120	24	124	4.0	46	130
1970	370	1,815	130	27	132	4.5	47	170
1975	420	1,972	140	29	136	4.9	44	200
1980	450	2,000	150	34	148	5.6	45	210
Consumption[2]								
1960	61	339	52	3.5	19	2.8	3.0	0.2
1965	78	403	66	5.2	27	3.2	3.4	0.4
1970	87	427	73	5.9	29	3.4	4.1	0.8
1975	96	440	80	6.7	31	3.4	4.2	1.9
1980	100	450	83	7.1	34	3.9	5.0	3.2

U.S. Water Withdrawals and Consumption, by End Use and Per Capita, 1900–1980—Continued

Table A-37
Water Resources

Year	Total (billion gal/day)	Total Per capita[1] (gal/day)	Irrigation (billion gal/day)	Public water utilities (billion gal/day)	Public water utilities Per capita[1] (gal/day)	Rural domestic (billion gal/day)	Industrial and miscella-neous (billion gal/day)	Steam electric utilities (billion gal/day)

Details may not add to totals due to independent rounding.
Data include 50 States and Puerto Rico.
[1]Per capita use of public water supplies was calculated using the total U.S. population although not all of the population in those years had public water supplies.
[2]Estimates of consumptive use prior to 1960 are not available.

Sources:
1900–1940: U.S. Department of Commerce, Business and Defense Services Administration, Walter L. Picton, *Water Use in the United States, 1900–1950* (1960), p.2
1950–1980: U.S. Geological Survey, *Estimated Use of Water in the United States in 1980,* Geological Survey Circular 1001 (Washington: USGPO, 1983), and previous quinquennial issues.

U.S. Endangered and Threatened Species, 1984
(species listings by class)

Table A-38
Fish and wildlife

	ENDANGERED[1]			THREATENED[2]			
	U.S. Only	U.S. & Foreign	Foreign Only	U.S. Only	U.S. & Foreign	Foreign Only	SPECIES[3] TOTAL
Mammals	15	19	233	3	0	22	292
Birds	52	14	144	3	0	0	213
Reptiles	8	6	60	8	4	13	99
Amphibians	5	0	8	3	0	0	16
Fishes	30	3	11	12	1	0	57
Snails	3	0	1	5	0	0	9
Clams	22	0	2	0	0	0	24
Crustaceans	3	0	0	1	0	0	4
Insects	7	0	0	4	2	0	13
Plants	60	3	0	9	2	2	76
Total	205	45	459	48	9	37	803

[1]An endangered species is in danger of becoming extinct throughout all or a significant part of its natural range.
[2]A threatened species is likely to become endangered in the foreseeable future.
[3]Separate population of a species, listed both as Endangered and Threatened, are tallied twice. Species which are thus accounted for are the gray wolf, bald eagle, American alligator, green sea turtle, and Olive ridley sea turtle.

Number of species currently proposed:	37 animals 34 plants
Number of Critical Habitats listed:	59
Number of Recovery Plans approved:	132
Number of Cooperative Agreements signed with States:	40 fish and wildlife 13 plants

Source: U.S. Department of the Interior, Fish and Wildlife Service, Office of Endangered Species, *Endangered Species Technical Bulletin* (Washington, D.C.: July 1984).

Breeding Population Estimates for 10 Species of Ducks, 1955–84
(in thousands)*

Year	Mallard	Gadwall	American wigeon	Green-winged teal	Blue-winged teal	Northern shoveler	Pintail	Redhead	Canvasback	Scaup
1955	10,345	1,106	3,333	2,076	6,436	1,965	9,251	733	595	7,100
1956	11,711	1,202	3,712	1,898	6,267	2,084	10,124	928	692	6,595
1957	10,946	1,102	3,208	1,293	5,449	1,744	6,856	684	600	6,535
1958	12,964	687	3,372	1,618	5,799	1,515	6,889	524	713	6,040
1959	10,292	683	3,779	3,153	5,300	1,649	7,228	641	481	8,220
1960	8,206	873	3,165	1,630	4,303	1,859	5,769	542	575	5,566
1961	8,290	1,422	3,219	2,216	4,833	1,625	4,860	437	396	6,764
1962	6,144	1,610	2,721	1,119	3,890	1,633	4,299	664	385	6,398
1963	7,360	1,578	2,209	1,754	4,587	1,435	4,361	396	523	6,564
1964	6,974	1,223	2,630	2,051	4,943	1,685	4,111	560	658	6,326
1965	5,948	1,692	2,695	1,526	4,628	1,607	4,301	568	505	5,383
1966	7,401	1,976	2,901	2,219	5,616	2,272	5,777	747	683	5,421
1967	8,205	1,638	2,637	1,944	4,715	2,244	5,870	846	556	5,877
1968	7,586	2,098	2,783	1,805	3,697	1,811	4,225	502	557	5,971
1969	8,065	1,837	3,192	1,991	4,514	2,150	6,390	759	530	6,338
1970	10,379	1,698	3,752	2,259	5,633	2,269	7,004	834	601	6,930
1971	9,843	1,733	3,425	2,352	5,426	2,052	6,291	693	441	6,149
1972	9,867	1,776	3,428	2,407	5,673	2,505	7,875	489	429	9,527
1973	8,781	1,198	3,665	2,444	4,866	1,657	5,114	754	696	7,535
1974	7,392	1,562	3,003	2,221	5,437	2,060	7,165	613	493	7,045

Breeding Population Estimates for 10 Species of Ducks, 1955–84—Continued
(in thousands)*

Year	Mallard	Gadwall	American wigeon	Green-winged teal	Blue-winged teal	Northern shoveler	Pintail	Redhead	Canvasback	Scaup
1975	8,109	1,672	2,862	2,038	6,441	1,994	6,387	974	706	7,846
1976	8,637	1,478	2,699	1,844	5,023	1,818	6,045	946	686	6,973
1977	8,226	1,546	2,678	1,952	4,626	1,616	4,971	688	702	7,490
1978	7,695	1,593	3,808	2,978	4,497	2,162	5,664	833	423	7,125
1979	8,444	1,889	3,388	2,920	5,278	2,555	6,070	774	606	9,135
1980	8,003	1,459	3,857	2,925	4,903	2,050	5,420	1,146	688	7,690
1981	6,757	1,479	3,555	2,515	4,076	2,403	4,227	825	594	7,253
1982	6,684	1,690	3,159	2,247	3,879	2,540	4,112	674	543	6,549
1983	7,107	1,536	2,923	2,574	3,381	2,237	4,086	866	528	8,788
1984	5,974	1,799	3,979	1,804	3,870	2,223	3,664	849	569	8,402
1955–83 Av.	8,493	1,484	3,164	2,137	4,970	1,972	5,888	712	572	6,936
Percent Change in 1984 from:										
1983	–16	+17	+36	–30	+14	–1	–10	–2	+8	–4
1955–83 Av.	–30	+21	+26	–16	–22	+13	–38	+19	–1	+21

*All duck indexes adjusted for visibility bias.
Source: U.S. Department of the Interior, Fish and Wildlife Service, Office of Migratory Bird Management, *Status of Water Fowl and Fall Flight Forecast, 1984* (Washington, D.C.: July 1984).

National Wildlife Refuge System and Related Areas of the U.S. Fish and Wildlife Service, 1900–1984, and by State, 1984

Table A-40
Fish and wildlife

Year[1]	Number of areas	Acres	Year[1]	Number of areas	Acres
1900	0	0	1975	702	34,165,000
1910	31	434,000	1976	712	34,387,000
1920	76	3,396,000	1977	719	34,545,000
1930	86	4,823,000	1978	723	34,633,000
1940	262	13,365,000	1979	735	46,802,000
1950	NA	17,421,000	1980	766	83,765,000
1960	475	17,968,000	1981	766	88,828,000
1970	624	30,724,000	1982	772	88,869,000
			1983	769	88,940,000
			1984	770	90,186,000
Alabama	9	50,934	Nebraska	13	157,097
Alaska	33	77,053,592	Nevada	13	2,372,097
Arizona	12	1,593,080	New Hampshire	3	2,229
Arkansas	10	204,942	New Jersey	4	40,005
California	34	293,447	New Mexico	11	382,167
Colorado	8	59,925	New York	11	23,522
Connecticut	1	183	N. Carolina	12	256,748
Delaware	3	25,403	N. Dakota	109	1,273,545
Florida	28	473,394	Ohio	5	8,685
Georgia	11	468,439	Oklahoma	7	140,927
Hawaii	7	255,825	Oregon	24	544,546

National Wildlife Refuge System and Related Areas of the U.S. Fish and Wildlife Service, 1900–1984, and by State, 1984—Continued

Year[1]	Number of areas	Acres	Year[1]	Number of areas	Acres
Idaho	16	85,072	Pennsylvania	5	9,173
Illinois	7	118,063	Rhode Island	4	1,244
Indiana	1	7,724	S. Carolina	10	189,506
Iowa	7	73,694	S. Dakota	53	499,495
Kansas	3	51,443	Tennesee	7	84,709
Kentucky	3	2,174	Texas	19	303,037
Louisiana	10	291,221	Utah	8	101,855
Maine	10	31,565	Vermont	3	5,943
Maryland	6	26,077	Virginia	11	104,971
Massachusetts	11	12,183	Washington	38	184,609
Michigan	17	110,001	W. Virginia	3	456
Minnesota	33	444,844	Wisconsin	20	221,079
Mississippi	9	115,584	Wyoming	15	75,556
Missouri	10	55,602			
Montana	52	1,154,556	Territories	11	143,787

[1]Years are fiscal years. Through 1976, refers to June 30 of year shown, from 1977 through 1984 refers to September 30.

Sources: U.S. Department of the Interior, Division of Realty, *Annual Report of Lands Under Control of the U.S. Fish and Wildlife Service as of September 30, 1984* (Washington, D.C.: 1985), and previous annual issues. U.S. Department of the Interior, Fish and Wildlife Service, unpublished data.

Selected Large Mammal Populations on Forest Service lands, 1960-1984

Year	Mule deer	Whitetail deer	Blacktail deer	Elk	Turkey	Black bear	Pronghorn antelope	Mountain goat	Moose	Javelina
1960	2,160,000	902,000	559,000	299,000	99,000	109,000	54,000	26,000	16,000	NA
1961	2,322,000	898,000	620,000	313,000	120,000	109,000	54,000	30,000	17,000	NA
1962	2,413,000	935,000	670,000	334,000	116,000	109,000	49,000	29,000	20,000	NA
1963	2,380,000	865,000	688,000	338,000	131,000	106,000	51,000	31,000	21,000	NA
1964	2,351,000	900,000	714,000	346,000	152,000	105,000	48,000	31,000	21,000	NA
1965	2,367,000	936,000	720,000	361,000	164,000	108,000	50,000	32,000	21,000	NA
1966	2,204,000	879,000	720,000	357,000	160,000	110,000	46,000	31,000	21,000	NA
1967	2,251,000	928,000	817,000	375,000	162,000	108,000	44,000	30,000	21,000	NA
1968	2,144,000	930,000	765,000	351,000	155,000	103,000	38,000	31,000	22,000	NA
1969	2,138,000	887,000	666,000	361,000	155,000	100,000	38,000	31,000	21,000	NA
1970	2,089,000	861,000	659,000	362,000	159,000	98,000	37,000	31,000	24,000	NA
1971	2,013,000	809,000	645,000	366,000	165,000	97,000	39,000	30,000	23,000	NA
1972	1,852,000	810,000	630,000	368,000	175,000	97,000	42,000	29,000	25,000	NA
1973	1,767,000	782,000	516,000	365,000	171,000	92,000	39,000	20,000	25,000	20,000
1974	1,662,000	824,000	506,000	387,000	175,000	93,000	42,000	27,000	25,000	21,000
1975	1,491,000	814,000	504,000	396,000	165,000	94,000	46,000	28,000	22,000	21,000
1976	1,396,000	783,000	519,000	401,000	169,000	96,000	45,000	24,000	23,000	20,000
1977	1,405,000	807,000	511,000	431,000	176,000	93,000	50,000	24,000	23,000	21,000
1978	1,444,000	797,000	537,000	415,000	199,000	93,000	60,000	25,000	23,000	20,000
1979	1,387,000	765,000	514,000	405,000	213,000	104,000	49,000	22,000	24,000	19,000

Selected Large Mammal Populations on Forest Service lands, 1960–1984—Continued

Year	Mule deer	Whitetail deer	Blacktail deer	Elk	Turkey	Black bear	Pronghorn antelope	Mountain goat	Moose	Javelina
1980	1,360,000	894,000	524,000	395,000	226,000	98,000	49,000	22,000	25,000	21,000
1981	1,464,000	764,000	563,000	428,000	230,000	100,000	48,000	22,000	25,000	22,000
1982	1,494,000	776,000	598,000	448,000	228,000	96,000	51,000	21,000	27,000	24,000
1983	1,474,071	778,637	564,277	462,198	235,049	97,599	59,681	23,301	27,625	24,701
1984	1,367,113	789,695	581,423	466,612	231,339	101,474	58,080	25,152	26,246	25,783

Year	Big-horn sheep	Moun-tain lion	Alli-gator	Alaska brown bear	Wild boar	Dall sheep	Wolf	Grizzly bear	Cari-bou	Bar-bary sheep	Bison
1960	11,000	NA	NA	6,200	1,400	1,000	NA	745	NA	NA	NA
1961	11,100	NA	NA	6,200	2,500	900	NA	775	NA	NA	NA
1962	11,100	NA	NA	6,200	2,000	900	NA	805	NA	NA	NA
1963	11,100	NA	NA	6,300	2,000	900	NA	820	NA	NA	NA
1964	12,100	NA	NA	6,300	2,100	900	NA	780	NA	NA	NA
1965	13,000	NA	NA	6,200	2,300	900	NA	900	NA	NA	NA
1966	13,000	NA	NA	6,300	2,400	900	2,500	900	150	NA	NA
1967	14,000	NA	NA	6,300	2,600	900	2,800	903	150	NA	NA
1968	13,000	NA	NA	6,400	2,700	900	2,700	829	175	NA	NA
1969	12,800	NA	NA	6,400	2,500	1,210	2,500	832	160	NA	NA
1970	12,800	NA	NA	8,400	1,900	1,210	2,700	830	125	NA	NA
1971	12,900	NA	NA	6,000	2,600	1,150	2,600	700	260	NA	NA

Selected Large Mammal Populations on Forest Service lands, 1960–1984—Continued

Year	Big-horn sheep	Moun-tain lion	Alli-gator	Alaska brown bear	Wild boar	Dall sheep	Wolf	Grizzly bear	Cari-bou	Bar-bary sheep	Bison
1972	12,900	NA	NA	6,000	3,300	1,150	2,000	800	280	NA	NA
1973	13,000	7,300	6,900	5,400	3,000	1,200	1,600	810	350	160	350
1974	13,000	8,400	6,500	5,400	3,200	1,200	1,400	670	360	270	310
1975	14,000	8,300	6,400	5,300	2,600	1,200	1,300	620	400	280	300
1976	15,000	8,400	7,200	5,300	2,800	1,200	1,400	620	400	310	230
1977	16,000	8,700	7,800	5,300	3,000	1,200	1,000	630	390	200	150
1978	17,000	9,300	8,000	5,300	3,000	1,200	1,400	670	400	210	180
1979	17,000	9,000	8,000	5,400	2,300	1,200	1,200	620	390	300	150
1980	17,800	9,400	7,500	4,900	2,600	1,200	1,270	592	285	404	407
1981	17,800	9,400	7,500	4,900	2,400	1,200	1,230	582	280	377	148
1982	19,400	10,100	8,600	4,700	2,700	1,750	1,250	494	518	251	165
1983	19,508	10,569	8,105	NA	3,019	1,840	1,145	486	323[3]	332	166
1984	19,652	11,091	8,125	NA	3,480	750[1]	1,206	5,006[2]	323	351	206

NA - Not available.
Data include selected big game animals in National Forests and National Grandlands.
[1]Improved estimating methods showed the Dall sheep population to be less than half the previous estimates.
[2]Includes 4,230 Grizzly bear in Alaska.
[3]Includes 300 Caribou estimated for Alaska.

Source: U.S. Department of Agriculture, Forest Service, Wildlife and Fisheries Staff, *Wildlife and Fish Habitat Management in the Forest Service* (Washington, D.C.: June 1985), and previous annual reports.

Animals Removed or Killed by Federal Animal Damage Control Activities, 1937–1983

Year[1]	Bear	Bobcat	Coyote	Red wolf[2]	Timber wolf	Mountain lion
1937	299	7,472	80,299	980	27	212
1938	392	7,189	84,844	1,343	17	255
1939	495	9,033	93,039	1,188	26	241
1940	608	10,566	104,072	1,246	9	214
1941	528	10,347	110,495	1,362	5	204
1942	636	10,957	111,076	781	10	204
1943	618	9,527	103,971	1,004	10	147
1944	592	8,900	108,050	1,161	9	167
1945	619	7,325	102,979	1,354	11	163
1946	730	6,487	108,311	1,551	6	113
1947	919	6,508	103,982	1,450	10	127
1948	744	7,223	90,270	1,053	14	148
1949	652	8,231	75,448	1,032	4	131
1950	719	10,874	66,281	1,051	108	236
1951	733	13,343	60,455	1,244	134	229
1952	714	13,476	50,661	1,451	182	197
1953	729	18,905	55,000	1,797	65	184
1954	860	19,559	52,636	1,589	93	232
1955	874	19,249	55,204	2,487	171	195
1956	977	19,495	55,402	1,940	96	285
1957	1,039	22,198	62,585	2,681	109	267
1958	1,023	23,453	62,765	2,615	172	331
1959	978	25,079	78,714	3,393	161	292
1960	1,023	25,808	94,769	3,830	2	290
1961	1,039	25,177	100,363	2,532	1	276
1962	815	21,228	104,787	2,780	2	254
1963	842	20,780	89,653	2,771	8	294
1964	711	20,918	97,096	2,617[3]	24	323
1965	605	17,294	90,236	—	15	280
1966	549	13,365	77,258	—	5	212
1967	499	11,031	75,982	—	9	143
1968	440	9,351	69,390	—	34	152
1969	399	8,443	74,070	—	14	145
1970	403	8,403	73,093	—	11	121
1971	234	6,608	75,661	—	14[3]	80
1972	191	5,351	71,298	—	—	49
1973	196	4,526	76,490	—	—	29
1974	86	3,790	71,777	—	—	24
1975	117	2,559	81,471	—	—	39

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Animals Removed or Killed by Federal Animal Damage Control Activities, 1937–1983—Continued

Table A-42
Fish and wildlife

Year[1]	Bear	Bobcat	Coyote	Red wolf[2]	Timber wolf	Mountain lion
1976	179	2,298	88,985	—	—	51
1977	92	1,018	65,649	—	—	60
1978	102	1,077	61,004	—	—	38
1979	133	1,197	65,351	—	—	63
1980	176	1,063	57,508	—	—	70
1981	190	407	57,178	—	—	83
1982	184	616	51,579	—	—	43
1983	146	677	63,236	—	—	112

[1]Years refer to fiscal years.
[2]Some hybrid animals, for example, red wolf/coyote and red wolf/dog, are included.
[3]Federal funding for taking red wolves ended in 1964. It ended for the timber wolf in 1971. Both are now endangered, although the timber wolf's endangerment does not include Alaska.

Sources:
1937–1970: Advisory Committee on Predator Control, *Predator Control 1971* (Washington: USGPO, 1972), p. 22.
1971–1983: U.S. Department of the Interior, Fish and Wildlife Service, Animal Damage Control Division, unpublished data.

U.S. Population of Selected Threatened and Endangered Species, 1941-1984

Year	Key deer	Whooping crane	California condor	Bald eagle[1]	Year	Key deer	Whooping crane	California condor	Bald eagle[1]
1941		21			1971				
1945			60		1972	600	80		
1948		16			1973				632
1949	30				1974				708
1951		25			1975				
1962			40	515	1976		96		
1963				487	1977				
1964	300				1978				1,155
1968		60	52		1979		123	28	
1969					1981				1,419
1970					1982	400	114	20	
					1983	400	143[2]	28[2]	1,500
					1984	400	NA	29	1,500

[1]Data for the bald eagle refer to nesting pairs in coterminus United States.
[2]1983 data includes captive and wild birds
NA - Not Available.

Sources:
Key deer, 1949-1972, and whooping crane, 1972: U.S. Fish and Wildlife Service, *Threatened Wildlife in the United States* (Washington: USGPO, 1973), p. 265; *Key deer, 1982-1984,* U.S. Department of the Interior, U.S. Fish and Wildlife Service, Office of Endangered Species, unpublished data.
Whooping crane, 1941-1968 and 1976-1983, and California condor, 1979-1983, U.S. Fish and Wildlife Service, Office of Endangered Species, unpublished data; *California condor, 1945-1984.*
Bald eagle, 1962-1981: U.S. Department of the Interior, Bureau of Land Management, *A Management Strategy for Bald Eagle Habitat Administered by the Bureau of Land Management,* Nancy F. Green (in preparation), *Bald eagle, 1984:* U.S. Fish and Wildlife Service, Office of Endangered Species, unpublished data.

Changes in North American Breeding Bird Populations, by Species, 1968–1981

Table A–44
Fish and wildlife

Scientific name	Common name	Number of species: Significant: Increase[1]	Significant: Decrease[1]	No change	Small sample (less than 15 routes)	Total species
Gaviformes	Loons			1	2	3
Podicipediformes	Grebes			5	1	6
Pelecaniformes	Pelicans and allies			4	9	13
Ciconiiformes	Herons, Storks, and Ibises	3		12	2	17
Anseriformes	Swans, Geese, and Ducks	4	1	20	12	37
Falconiformes	Vultures and Hawks	4	1	19	6	30
Galliformes	Grouse, Quail, Pheasants, and Turkey	1	2	7	9	19
Gruiformes	Cranes, Limpkins, Rails, and Coots	1	1	6	5	13
Charadriiformes	Shorebirds, Gulls, Terns, and Skimmers	6	1	26	32	65
Columbiformes	Pigeons and Doves	2	1	3	5	11
Cuculiformes	Cuckoos, Roadrunners, and Anis	2		1	3	6
Strigiformes	Owls	1	1	8	5	13
Caprimulgiformes	Nightjars			5	1	6
Apodiforms	Swifts and Hummingbirds	1		11	5	17
Trogoniformes	Trogons				1	1
Coraciiformes	Kingfishers			1	1	2
Piciformes	Woodpeckers	2	3	11	4	20
Tyrannidae	Tyrant Flycatchers	3	5	15	8	31
Corvidae	Jays, Magpies, and Crows	3		10	2	15
Paridae	Titmice, Verdins, and Bushtits	1	1	8	2	12
Troglodytidae	Wrens	1	4	4		9

Changes in North American Breeding Bird Populations, by Species, 1968-1981—Continued

Scientific name	Common name	Number of species: Significant Increase[1]	Significant Decrease[1]	No change	Small sample (less than 15 routes)	Total species
Mimidae	Mockingbirds and Thrashers		2	7	1	10
Turdidae	Thrushes	2	2	7	1	12
Vireonidae	Vireos	2	2	5	2	11
Parulidae	Wood Warblers	10	3	32	5	50
Icteridae	Meadowlarks, Blackbirds, and Orioles	5	1	12	2	20
Fringillidae	Grosbeaks, Finches, Sparrows, and Buntings	4	13	39	9	65
Other families (14)		8	2	19	7	36
Total		66	46	298	140	550

The Breeding Bird Survey measures the number of bird species annually. North America is divided into 62 ecological regions. All birds seen or heard with a quarter-mile radius during the 3-minute stops spaced at half-mile intervals along randomly selected 24.5-mile routes, of which there are 2,300, are counted. One-degree blocks of latitude and longitude are used as a basis for route selection to ensure good geographic distribution of routes. Both starting point and direction of travel are determined from a table of random numbers.

This list includes species observed for 2 or more years on one or more routes of study. Therefore, the rarer birds may not be included in this list.

[1]The number of species with significant increases are not strictly comparable to the number of species with significant decreases. The statistical methods used to calculate significant increases and decreases may underestimate the actual number of species declining.

Source: U.S. Fish and Wildlife Service, Patuxent Wildlife Research Center, Breeding Bird Survey, unpublished data.

U.S. and Foreign Fish Catch in U.S. Water, 1950–1983
(billion pounds)

Table A-45
Fish and wildlife

Year	U.S. catch[1]	Foreign catch in U.S. waters[2]	Total	Year	U.S. catch[1]	Foreign catch in U.S. waters[2]	Total
1950	4.851	NA	NA	1966	4.190	NA	NA
1951	4.410	NA	NA	1967	3.969	NA	NA
1952	4.410	NA	NA	1968	4.190	NA	NA
1953	4.410	NA	NA	1969	4.190	5.733	9.923
1954	4.851	NA	NA	1970	4.917	6.615	11.532
1955	4.851	NA	NA	1971	5.018	7.718	12.736
1956	5.292	NA	NA	1972	4.806	7.277	12.083
1957	4.851	NA	NA	1973	4.858	7.056	11.914
1958	4.851	NA	NA	1974	4.967	6.836	11.803
1959	5.072	NA	NA	1975	4.877	5.954	10.831
1960	4.851	NA	NA	1976	5.388	5.072	10.460
1961	5.292	NA	NA	1977	5.198	3.749	8.947
1962	5.292	NA	NA	1978	6.028	3.868	9.896
1963	4.851	NA	NA	1979	6.267	3.637	9.904
1964	4.631	NA	NA	1980	6.482	3.596	10.078
1965	4.851	NA	NA	1981	5.977	3.648	9.625
				1982	6.367	3.119	9.486
				1983	7.093	5.956	13.049

NA - Not available.
[1]U.S. catch excludes weight of mollusk shells.
[2]U.S. waters extend out 200 miles from the coast.

Sources:
Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, *Fisheries of the United States, 1983* (Washington, D.C.: 1984), and earlier issues; and unpublished data.

Fish Kills Caused by Pollution, 1961–1981

Year	Number of States responding	Number of reports	Reports listing number of fish killed	Total number of fish killed	Average size of kill[1]	Largest kill reported
1961	45	413	265	14,910,000	6,535	5,387,000
1962	37	421	246	44,001,000	5,710	3,180,000
1963	38	442	304	6,937,000	7,775	2,000,000
1964	40	590	470	22,914,000	5,490	7,887,000
1965	44	625	520	12,140,000	4,310	3,000,000
1966	46	532	453	9,614,000	5,620	1,000,000
1967	40	454	364	11,291,000	6,460	6,549,000
1968	42	542	469	15,815,000	6,015	4,029,000
1969	45	594	492	41,166,000	5,860	25,527,000
1970	45	635	563	22,290,000	6,412	3,240,000
1971	46	860	759	73,670,000	6,154	5,500,000
1972	50	760	697	17,717,000	4,639	2,922,000
1973	50	749	703	37,814,000	5,527	10,000,000
1974	50	721	648	119,052,000	6,532	47,112,000
1975	50	624	543	16,111,210	3,879	10,000,000
1976	50	667	601	13,611,049	4,509	4,800,000
1977	41	503	449	16,538,936	4,386	8,592,000
1978	42	679	621	74,712,651	3,487	33,000,000
1979	47	770	673	8,105,371	4,292	1,000,000
1980	43	801	747	29,949,097	4,046	5,000,000
1981	43	836	760	50,192,644	3,354	25,000,000

Fish Kills Caused by Pollution, 1961–1981—Continued

Year	Total Reports	Number of reported incidents for each pollution source operation Agricultural	Industrial	Municipal[2]	Transportation	Other	Unknown
1961	413	74	169	52	0	58	60
1962	421	51	209	33	1	47	80
1963	442	84	199	60	17	27	55
1964	590	131	193	120	26	17	103
1965	625	114	244	125	27	23	92
1966	532	88	195	87	27	38	97
1967	454	87	139	91	23	35	79
1968	542	77	177	122	39	23	104
1969	594	117	199	84	32	33	129
1970	635	108	213	120	28	28	138
1971	860	132	231	162	52	64	219
1972	760	113	189	167	56	72	163
1973	749	161	196	146	65	56	125
1974	721	145	168	169	40	74	125
1975	624	118	122	90	47	78	169
1976	667	151	112	133	50	67	154
1977	503	93	95	107	37	51	120
1978	679	137	124	114	44	60	200
1979	770	190	116	100	65	89	210
1980	801	155	141	137	42	143	183
1981	836	201	144	100	46	156	189

[1]Derived after excluding reports of 100,000 or more fish killed as being unrepresentative.
[2]Municipal operations include electric generating stations.

Sources:
1961–1976: U.S. Environmental Protection Agency, *Fish Kills Caused by Pollution in 1976* (Washington, D.C.: 1979), pp. 4, 5.
1977–1981: U.S. Environmental Protection Agency, unpublished data.

Designated Critical Habitats of Threatened and Endangered Species, 1984

Table A-47
Fish and wildlife

Common name	Scientific name	Year Critical Habitat determined	Affected States (Areas)[1]
Mammals			
Bat, Indiana	Myotis sodalis	1976	IL IN KY MO TN WV
Bat, Virginia big-eared	Plecotus townsendii virginianus	1979	WV
Manatee, Florida	Trichechus manatus	1976	FL
Rat, Morro Bay kangaroo	Dipodomys heermanni morroensis	1977	CA
Wolf, gray	Canis lupus	1978	MI MN
Birds			
Blackbird, yellow-shouldered	Agelaius xanthomus	1976	PR
Condor, California	Gymnogyps californianus	1976	CA
Crane, Mississippi sandhill	Grus canadensis pulla	1977	MS
Crane, whooping	Grus americana	1978	CO ID KS NE NM OK TX
Falcon, American peregrine	Falco peregrinus anatum	1977	CA
Kite, Everglade	Rostrhamus sociabilis	1977	FL
Palila	Psittirostra bailleui	1977	HI
Sparrow, Cape sable	Ammospiza maritima mirabilis	1977	FL
Sparrow, dusky seaside	Ammospiza maritima nigrescens	1977	FL
Reptiles			
gecko, Monito	Sphaerodactylus-micropithecus	1982	PR
Boa, Mona	Epicrates monensis monensis	1978	PR
Anole, Giant	Anolis roosevelti	1977	PR
Crocodile, American	Crocodylus acutus	1976	FL
Iguana, Mona ground	Cyclura stejnegeri	1978	PR

Designated Critical Habitats of Threatened and Endangered Species, 1984—Continued

Table A-47
Fish and wildlife

Common name	Scientific name	Year Critical Habitat determined	Affected States (Areas)[1]
Lizard, Coachella Valley fringe-toed	Uma inornata	1980	CA
Lizard, St. Croix ground	Ameiva polops	1977	VI
Rattlesnake, New Mexican ridge-nosed	Crotalus willardi obscurus	1978	NM
Tortoise, desert	Gorpherus agassizii	1980	UT
sea turtle, Hawksbill	Eretmochelys imbricata	1982	PR
Turtle, leatherback sea	Dermocheys coriacea	1970	VI
Turtle, Plymouth red-bellied	Pseudemys rubiyentris bangsi	1980	MA
Amphibians			
Coqui, golden	Eleutherodactylus jasperi	1977	PR
Salamander, San Marcos	Eurycea nana	1980	TX
Toad, Houston	Bufo houstonensis	1978	TX
Fishes			
Catfish, Yaqui	Ictalurus pricei	1984	AR
Cavefish, Alabama	Speoplatyrhinus poulsoni	1977	AL
Chub, Lake Borax	Gila boraxobius	1982	OR
Chub, slender	Hybopsis cahni	1977	TN VA
Chub, spotfin	Hybopsis monacha	1977	VA TN NC
Chub, Yaqui	Gila Purpurea	1984	AR
Dace, Ash Meadows speckled	Rhinschthys osculus nevadenis	1983	NV
Darter, fountain	Etheostoma tonticola	1980	TX
Darter, leopard	Percina pantherina	1978	AK OK

Designated Critical Habitats of Threatened and Endangered Species, 1984—Continued

Table A-47
Fish and wildlife

Common name	Scientific name	Year Critical Habitat determined	Affected States (Areas)[1]
Darter, Maryland	Etheostoma stellare	1984	MD
Darter, slackwater	Etheostoma boschungi	1977	AL TN
Gambusia, San Marcos	Gambusia georgei	1980	TX
Madtom, yellowfin	Noturus flavipinnis	1977	TN VA
Pupfish, Ash Meadows Amargosa	Cyprinodon nevadenis mionectes	1983	NV
Pupfish, Leon Springs	Cyprinodon bovinus	1980	TX
Shiner, beautiful	Notropis formosis	1984	AR
Trout, little kern golden	Solmo aguabonita whitea	1978	CA
Crustaceans			
Shrimp, Kentucky cave	Palaemonias ganteri	1984	KY
Insects			
Beetle, Delta green ground	Elaphrus viridis	1980	CA
Beetle, Valley elderberry longhorn	Desmocerus californicus dimorphus	1980	CA
Butterfly, Oregon silverspot	Speyeria zerene hippolyta	1980	OR
Butterfly, Palos Verdes blue	Glaucopsyche lygdamus palosverdesensis	1980	CA
Flowering Plants			
Lettuce, Malheut Wire	Stephanomeria malheutensis	1982	OR
Groundsel, San Francisco Peak	Senecio Franciscanus	1982	AR
Wallflower, Contra Costa	Erysimum capitatum var. angustatum	1978	CA

Designated Critical Habitats of Threatened and Endangered Species, 1984—Continued

Table A-47
Fish and wildlife

Common name	Scientific name	Year Critical Habitat determined	Affected States (Areas)[1]
Heather, Mountain Golden	Hudsonia montana	1984	NC
Pennyroyal, McKittrick's	Hedeona apiculatum	1982	NM TX
Pennyroyal, Todsen's	Hedeona todsenii	1981	NM
Primrose, Antioch Dunes evening	Oenothera deltoides ssp howellii	1978	CA
Panicgrass, Carter's	Panicom carteri	1984	HI
Buckwheat, Gypsum wild	Eriogonum gypsophilum	1981	NM
Buckwheat; Clayloving wild	Eriogonum pelinophilum	1984	CO
Rice, Texas wild	Zizania texana	1980	TX
Cinquefoil, Robbins'	Potentilla robbinsiana	1980	NH

Critical Habitats are areas which endangered and threatened species depend upon for survival. In these areas, federal agencies must ensure that their activities do not adversely modify or destroy the habitat or jeopardize the continued existence of the species. Critical Habitats are designated by the Secretary of the Interior and are published in the Federal Register.

[1]Specific areas within affected states are designated Critical Habitats. These areas range in size from 15 acres for the St. Croix ground lizard in the Virgin Islands to 4.6 million acres for the gray wolf in Minnesota. A state may contain more than one Critical Habitat for a specific species. More than 100 Critical Habitats have been designated in the United States for the endangered and threatened species shown here.

Sources: U.S. Fish and Wildlife Service, Office of Endangered Species, *Endangered Species Technical Bulletins* (Washington, D.C.: 1982), unpublished data, and 50 C.F.R. Sections 17.95, 17.96, Revised October 1, 1984.

U.S. Nuclear Reactors Built, Being Built, or Planned, 1973–1985

	Nuclear reactors					Nuclear reactors			
Year[1]	Built[2]	Being built[3]	Planned[4]	Total	Year[1]	Built[2]	Being built[3]	Planned[4]	Total
1973	42	56	116	214	1979	70	91	27	188
1974	53	63	117	233	1980	70	82	11	163
1975	56	69	111	236	1981	73	78	11	162
1976	63	71	101	235	1982	77	64	5	146
1977	67	80	74	221	1983	78	57	1	136
1978	70	90	47	207	1985	93	34	0	127

[1]Data are as of December 31 of the year indicated, except for: 1981, which were as of Sept. 30; 1982 as of October; 1983 as of September 30; and 1985 as of May 31.
[2]Includes reactors licensed to operate and licensed for low-power or zero-powered testing.
[3]Includes reactors which have had construction permits granted.
[4]Includes reactors under construction permit review and those which have been ordered or announced

Sources:
1973–1980: U.S. Nuclear Regulatory Commission, Office of Management and Program Analysis, *Program Summary Report* (Springfield, Va.: National Technical Information Service), monthly issues;
1981: U.S. Nuclear Regulatory Commission, Office of Management and Program Analysis, "Status of Nuclear Power Plant Units Chart," data as of September 30, 1981, unpublished;
1982–1983: William Lovelace, U.S. Nuclear Regulatory Commission, unpublished data; *1985:* U.S. Nuclear Regulatory Commission, unpublished data.

Table A-49
Energy

U.S. Coal Production by Underground and Surface Mining, 1952–1983
(million short tons)

Year	Method of Mining			Year	Method of Mining		
	Underground	Surface	Total		Underground	Surface	Total
1952	381.2	126.3	507.4	1968	346.6	210.1	556.7
1953	367.4	120.8	488.2	1969	349.2	221.7	571.0
1954	306.0	114.8	420.8	1970	340.5	272.1	612.7
1955	358.0	132.9	490.8	1971	277.2	283.7	560.9
1956	380.8	148.9	529.8	1972	305.0	297.4	602.5
1957	373.6	144.5	518.0	1973	300.1	298.5	598.6
1958	297.6	134.0	431.6	1974	278.0	332.1	610.0
1959	292.8	139.8	432.7	1975	293.5	361.2	654.6
1960	292.6	141.7	434.3	1976	295.5	389.4	684.9
1961	279.6	140.9	420.4	1977	266.6	430.6	697.2
1962	287.9	151.1	439.0	1978	242.8	427.4	670.2
1963	309.0	168.2	477.2	1979	320.9	460.2	781.1
1964	327.7	176.5	504.2	1980	337.5	492.2	829.7
1965	338.0	189.0	527.0	1981	316.5	507.3	823.8
1966	342.6	204.2	546.8	1982[1]	312.1	511.9	824.0
1967	352.4	212.5	564.9	1983[1]	310.8	474.1	784.9

[1]Preliminary.
Note: Sum of components may not be equal total due to independent tounding.

Source: U.S. Department of Energy, Energy Information Administration, *1983 Annual Energy Review* (Washington, D.C.: 1984), p. 167.

Solar Collectors Manufactured, by Type, 1974–1982

Year	Low-temperature collectors[1]		Medium-temperature, special, and other collectors[2]	
	Number of manufacturers	Quantity manufactured (million square feet)	Number of manufacturers	Quantity manufactured (million square feet)
1974	6	1.14	39	0.14
1975	13	3.03	118	0.72
1976	19	3.88	203	1.92
1977	52	4.74	297	5.57
1978	81	5.87	180	4.99
1979	74	8.39	250	5.86
1980	73	12.23	245	7.16
1981	75	8.56	267	11.39
1982	61	7.48	247	11.14

[1]Low-temperature collectors are used almost exclusively for swimming pool heating.
[2]Medium-temperature collectors are used primarily for space heating and domestic water heating. Special collectors include evacuated-tube collectors and concentrating collectors; uses include domestic water heating, space heating, and space cooling.

Sources: 1974–1982: U.S. Department of Energy, Energy Information Administration, *1983 Annual Energy Review* (Washington, D.C.: 1984) p. 225.

U.S. Production of Electricity by the Electric Utility Industry, by Type of Generation, 1952–1983[1]
(billion kilowatt-hours)

Year	Conventional steam[2]	Internal combustion	Gas turbine	Nuclear power	Hydropower	Geothermal and other[3]	Total
1952	290	4	0	0	105	(4)	399
1953	333	4	0	0	105	(4)	443
1954	361	4	0	0	107	(4)	472
1955	430	4	0	0	113	(4)	547
1956	474	4	0	0	122	(4)	601
1957	497	4	0	(4)	130	(4)	632
1958	500	4	0	(4)	140	(4)	645
1959	567	4	0	(4)	138	(4)	710
1960	603	4	0	1	146	(4)	753
1961	634	5	0	2	152	(4)	792
1962	677	5	0	2	168	(4)	852
1963	742	5	(4)	3	166	(4)	917
1964	798	5	1	3	177	(4)	984
1965	851	5	1	4	194	(4)	1,055
1966	938	5	NA	6	195	1	1,144
1967	980	5	NA	8	222	1	1,214
1968	1,084	5	4	13	222	1	1,329
1969	1,163	6	8	14	250	1	1,442
1970	1,240	6	16	22	248	1	1,532
1971	1,279	6	22	38	266	1	1,613
1972	1,385	7	29	54	273	2	1,750
1973	1,467	7	30	83	272	2	1,861
1974	1,411	6	32	114	301	3	1,867
1975	1,414	6	22	173	300	3	1,918

U.S. Production of Electricity by the Electric Utility Industry, by Type of Generation, 1952–1983[1] (billion kilowatt-hours)—Continued

Year	Conventional steam[2]	Internal combustion	Gas turbine	Nuclear power	Hydropower	Geothermal and other[3]	Total
1976	1,530	5	24	191	284	4	2,038
1977	1,615	5	29	251	220	4	2,124
1978	1,610	5	31	276	280	3	2,206
1979	1,676	4	28	255	280	4	2,247
1980	1,726	4	24	251	276	6	2,286
1981	1,730	3	22	273	261	6	2,295
1982[5]	1,628	2	14	283	309	5	2,242
1983[5]	1,662	2	14	292	332	6	2,309

Details may not add to totals due to independent rounding.
NA - Not available.
[1]Represents gross electricity output measured at the generator terminals minus power plant use.
[2]Excludes geothermal and other.
[3]Includes production from plants which consume wood, refuse, and other vegetal fuels.
[4]Less than 0.5 billion kilowatt-hours.
[5]Preliminary

Source: U.S. Department of Energy, Energy Information Administration, *1983 Annual Energy Review* (Washington, D.C.: 1984), p. 195.

U.S. Trade in Energy, by Fuel Type, 1952–1983
(Quadrillion Btu)

	Exports - imports = net trade[1]						Exports - imports = net trade[1]				
	Coal[2]	Petro-leum[3]	Natural gas (dry)	Other[4]	Total		Coal[2]	Petro-leum[3]	Natural gas (dry)	Other[4]	Total
1952	1.40	0.91	0.03	0.02	2.37	1968	1.38	0.49	0.10	0.07	2.03
	0.01	2.11	0.01	0.04	2.17		0.01	6.21	0.67	0.04	6.93
	1.40	−1.20	0.02	−0.02	0.20		1.37	−5.73	−0.58	0.02	−4.90
1953	0.98	0.84	0.03	0.02	1.87	1969	1.53	0.49	0.05	0.08	2.15
	0.01	2.28	0.01	0.04	2.34		([5])	6.90	0.75	0.06	7.71
	0.97	−1.44	0.02	−0.02	−0.47		1.53	−6.42	−0.70	0.03	−5.56
1954	0.91	0.75	0.03	0.01	1.70	1970	1.94	0.55	0.07	0.11	2.66
	0.01	2.32	0.01	0.04	2.37		([5])	7.47	0.85	0.07	8.39
	0.91	−1.58	0.02	−0.02	−0.67		1.93	−6.92	−0.77	0.04	−5.72
1955	1.46	0.77	0.03	0.02	2.29	1971	1.55	0.47	0.08	0.08	2.18
	0.01	2.75	0.01	0.06	2.83		([5])	8.54	0.96	0.08	9.58
	1.46	−1.98	0.02	−0.04	−0.54		1.54	−8.07	−0.88	-([5])	−7.41
1956	1.98	0.91	0.04	0.02	2.95	1972	1.53	0.47	0.08	0.06	2.14
	0.01	3.17	0.01	0.06	3.25		([5])	10.30	1.05	0.11	11.46
	1.98	−2.26	0.03	−0.04	−0.30		1.53	−9.83	−0.97	−0.05	−9.32
1957	2.17	1.20	0.04	0.04	3.45	1973	1.45	0.49	0.08	0.06	2.07
	0.01	3.46	0.04	0.06	3.57		([5])	13.47	1.06	0.20	14.73
	2.16	−2.26	([5])	−0.02	−0.12		1.44	−12.98	−0.98	−0.14	−12.66
1958	1.42	0.58	0.04	0.02	2.06	1974	1.64	0.46	0.08	0.06	2.24
	0.01	3.72	0.14	0.05	3.92		0.05	13.13	0.99	0.25	14.42
	1.41	−3.14	−0.10	−0.03	−1.86		1.58	−12.66	−0.91	−0.19	−12.18

1959	1.05	0.45	0.02	0.02	1.54	1975	1.79	0.44	0.07	0.09	2.39
	0.01	3.91	0.14	0.05	4.11		0.02	12.95	0.98	0.16	14.11
	1.04	–3.46	–0.12	–0.03	–2.57		1.77	–12.51	–0.90	–0.08	–11.73
1960	1.02	0.43	0.01	0.02	1.48	1976	1.62	0.47	0.07	0.06	2.21
	0.01	4.00	0.16	0.06	4.23		0.03	15.67	0.99	0.15	16.84
	1.02	–3.57	–0.15	–0.04	–2.74		1.59	–15.20	–0.92	–0.09	–14.63
1961	0.98	0.37	0.01	0.02	1.38	1977	1.47	0.51	0.06	0.06	2.10
	(5)	4.19	0.23	0.04	4.46		0.04	18.76	1.04	0.26	20.09
	0.98	–3.82	–0.22	–0.02	–3.08		1.42	–18.24	–0.98	–0.20	–18.00
1962	1.08	0.36	0.02	0.03	1.48	1978	1.10	0.77	0.05	0.03	1.95
	0.01	4.56	0.42	0.03	5.01		0.07	17.82	0.99	0.37	19.26
	1.08	–4.20	–0.40	(5)	–3.53		1.02	–17.06	–0.94	–0.34	–17.31
1963	1.36	0.44	0.02	0.03	1.85	1979	1.78	1.00	0.06	0.06	2.90
	0.01	4.65	0.42	0.03	5.10		0.05	17.93	1.30	0.34	19.62
	1.35	–4.21	–0.40	0.01	–3.25		1.73	–16.93	–1.24	–0.28	–16.72
1964	1.34	0.43	0.02	0.06	1.85	1980	2.40	1.16	0.05	0.10	3.71
	0.01	4.96	0.46	0.07	5.49		0.03	14.66	1.01	0.28	15.97
	1.33	–4.53	–0.44	–0.01	–3.65		2.37	–13.50	–0.96	–0.18	–12.27
1965	1.38	0.39	0.03	0.06	1.86	1981	2.94	1.26	0.06	0.05	4.32
	0.00	5.40	0.47	0.04	5.92		0.03	12.64	0.92	0.36	13.94
	1.37	–5.01	–0.44	0.02	–4.06		2.92	–11.38	–0.86	–0.31	–9.62
1966	1.35	0.41	0.03	0.06	1.85	1982[6]	2.78	1.73	0.06	0.06	4.63
	(5)	5.63	0.50	0.05	6.18		0.02	10.61	0.99	0.36	11.97
	1.35	–5.21	–0.47	0.01	–4.32		2.77	–8.88	–0.93	–0.30	–7.35
1967	1.35	0.65	0.08	0.06	2.15	1983[6]	2.04	1.57	0.06	0.06	3.72
	0.01	5.56	0.58	0.04	6.19		0.03	10.50	0.96	0.39	11.88
	1.35	–4.91	–0.50	0.02	–4.04		2.01	–8.94	–0.91	–0.33	–8.16

U.S. Trade in Energy, by Fuel Type, 1952–1983—Continued
(Quadrillion Btu)

Exports - imports = net trade[1]					Exports - imports = net trade[1]				
Coal[2]	Petroleum[3]	Natural gas (dry)	Other[4]	Total	Coal[2]	Petroleum[3]	Natural gas (dry)	Other[4]	Total

[1]Details may not add to totals due to independent rounding. For example, 1.40 – 0.01 = 1.40 (Coal, 1952).
[2]Bituminous coal, lignite, and anthracite.
[3]Crude oil and refined petroleum products, including unfinished oils and natural gas plant liquids. Includes imports into the Strategic Petroleum Reserve which began in 1977.
[4]Coal coke and small amounts of electricity transmitted across U.S. borders with Canada and Mexico.
[5]Less than 0.005 quadrillion Btu.
[6]Preliminary.

Source: U.S. Department of Energy, Energy Information Administration, *1983 Annual Energy Review* (Washington, D.C.: 1984), p. 28.

U.S. Energy Production, by Fuel Type, 1952–1984

Year	Total energy production	Change from previous year	Coal[3]		Natural gas[4]		Petroleum[5]		Natural gas plant liquids	
	Quads[1]	Percent[2]	Quads[1]	Million short tons	Quads[1]	Trillion cubic feet	Quads[1]	Million barrels	Quads[1]	Million barrels
1952	36.95	−2.4	13.23	507.4	7.96	7.69	13.28	2,290	1.00	224
1953	37.24	0.8	12.74	488.2	8.35	8.06	13.67	2,357	1.06	239
1954	35.56	−4.5	10.98	420.8	8.68	8.39	13.43	2,315	1.11	252
1955	39.08	9.9	12.72	490.8	9.34	9.03	14.41	2,484	1.24	281
1956	41.62	6.5	13.72	529.8	10.00	9.66	15.18	2,617	1.28	293
1957	42.00	0.9	13.42	518.0	10.61	10.25	15.18	2,617	1.29	295
1958	39.21	−6.7	11.18	431.6	10.94	10.57	14.20	2,449	1.29	295
1959	40.90	4.3	11.08	432.7	11.95	11.55	14.93	2,575	1.38	321
1960	41.78	2.2	11.12	434.3	12.66	12.23	14.93	2,575	1.46	340
1961	42.27	1.2	10.73	420.4	13.10	12.66	15.21	2,622	1.55	362
1962	43.88	3.8	11.21	439.0	13.72	13.25	15.52	2,676	1.59	373
1963	46.16	5.2	12.15	447.2	14.51	14.08	15.97	2,753	1.71	401
1964	48.03	4.1	12.83	504.2	15.30	14.82	16.16	2,787	1.80	422
1965	49.67	3.4	13.38	527.0	15.78	15.29	16.52	2,849	1.88	442
1966	52.52	5.7	13.82	546.8	17.01	16.47	17.56	3,028	2.00	469
1967	55.41	5.5	14.19	564.9	17.94	17.39	18.65	3,216	2.18	514
1968	57.13	3.1	13.93	556.7	19.07	18.49	19.31	3,329	2.32	550
1969	59.44	4.0	14.20	571.0	20.45	19.83	19.56	3,372	2.42	580

U.S. Energy Production, by Fuel Type, 1952–1984—Continued

Year	Total energy production	Change from previous year	Coal[3]		Natural gas[4]		Petroleum[5]		Natural gas plant liquids	
	Quads[1]	Percent[2]	Quads[1]	Million short tons	Quads[1]	Trillion cubic feet	Quads[1]	Million barrels	Quads[1]	Million barrels
1970	62.51	5.2	15.05	612.7	21.67	21.01	20.40	3,517	2.51	606
1971	61.70	−1.3	13.59	560.9	22.28	21.61	20.03	3,454	2.54	618
1972	62.81	1.8	14.49	602.5	22.21	21.62	20.04	3,455	2.60	638
1973	62.43	−0.6	14.37	598.6	22.19	21.73	19.49	3,361	2.57	634
1974	61.23	−1.9	14.47	610.0	21.21	20.71	18.57	3,203	2.47	616
1975	60.06	−1.9	15.19	654.6	19.64	19.24	17.73	3,057	2.37	596
1976	60.09	0.1	15.85	684.9	19.48	19.10	17.26	2,976	2.33	587
1977	60.29	0.3	15.83	697.2	19.57	19.16	17.45	3,009	2.33	590
1978	61.23	1.5	15.04	670.2	19.49	19.12	18.43	3,178	2.25	572
1979	63.85	4.4	17.65	781.1	20.08	19.66	18.10	3,121	2.29	578
1980	64.81	1.5	18.64	829.7	19.92	19.60	18.25	3,146	2.25	576
1981	64.43	−0.6	18.44	823.8	19.69	19.40	18.15	3,129	2.31	587
1982	63.89	−0.8	18.64	838.1	18.25	17.76	18.31	3,157	2.19	566
1983	61.20	−4.2	17.25	782.1	16.53	16.03	18.39	3,172	2.18	569
1984[9]	65.51	7.0	19.70	890.1	17.75	17.22	18.59	3,197	2.37	595

P00000123714

Year	Hydropower[6]		Nuclear power		Geothermal		Wood and waste[7]	
	Quads	Billion kWh	Quads	Billion kWh	Quads	Billion kWh	Quads	Billion kWh
1952	1.47	109.7	0	0	0	0	0	0
1953	1.41	109.6	0	0	0	0	0	0
1954	1.36	111.6	0	0	0	0	0	0
1955	1.36	116.2	0	0	0	0	0	0
1956	1.43	125.2	0	0	0	0	0	0
1957	1.52	133.4	0	0	0	0	0	0
1958	1.59	143.6	([8])	0.2	0	0	0	0
1959	1.55	141.2	([8])	0.2	0	0	0	0
1960	1.60	149.1	0.01	0.5	0	0	([8])	0.1
1961	1.65	155.2	0.02	1.7	([8])	0.1	([8])	0.1
1962	1.81	171.7	0.03	2.3	([8])	0.1	([8])	0.1
1963	1.77	169.0	0.04	3.2	([8])	0.2	([8])	0.1
1964	1.89	180.3	0.04	3.3	([8])	0.2	([8])	0.1
1965	2.06	197.0	0.04	3.7	([8])	0.2	([8])	0.3
1966	2.06	197.9	0.06	5.5	([8])	0.2	([8])	0.3
1967	2.35	224.9	0.09	7.7	0.01	0.3	([8])	0.3
1968	2.35	225.9	0.14	12.5	0.01	0.4	([8])	0.4
1969	2.65	253.5	0.15	13.9	0.01	0.6	([8])	0.3
1970	2.63	251.0	0.24	21.8	0.01	0.5	([8])	0.4
1971	2.82	269.5	0.41	38.1	0.01	0.5	([8])	0.3
1972	2.86	275.9	0.58	54.1	0.03	1.5	([8])	0.3
1973	2.86	275.4	0.91	83.5	0.04	2.0	([8])	0.3
1974	3.18	304.2	1.27	114.0	0.05	2.5	([8])	0.3

U.S. Energy Production, by Fuel Type, 1952-1984—Continued

Year	Hydropower[6]		Nuclear power		Geothermal		Wood and waste[7]	
	Quads	Billion kWh	Quads	Billion kWh	Quads	Billion kWh	Quads	Billion kWh
1975	3.15	303.2	1.90	172.5	0.07	3.2	([8])	0.2
1976	2.98	286.9	2.11	191.1	0.08	3.6	([8])	0.3
1977	2.33	223.6	2.70	250.9	0.08	3.6	0.01	0.5
1978	2.96	283.5	2.98	276.4	0.06	3.0	([8])	0.3
1979	2.95	283.1	2.75	255.2	0.08	3.9	0.01	0.5
1980	2.90	279.2	2.74	251.1	0.11	5.1	([8])	0.4
1981	2.74	263.8	2.97	272.7	0.12	5.7	([8])	0.4
1982	3.26	309.0	3.13	282.8	0.10	4.8	([8])	0.3
1983	3.50	332.0	3.20	293.7	0.13	6.1	([8])	0.4
1984[9]	3.39	321.0	3.55	325.2	0.16	7.7	0.01	0.5

Details may not add to totals due to independent rounding.
[1]A quad equals one quadrillion Btu. A Btu is the amount of energy required to raise the temperature of one pound of water 1 degree Farenheit at or near 39.2 degrees Farenheit.
[2]Percent change calculated from data prior to rounding.
[3]Bituminous coal, lignite, and anthracite.
[4]Dry marketed natural gas.
[5]Crude oil and lease condensate.
[6]Electric utility and industrial generation of hydropower.
[7]Wood, refuse, and other vegetal fuels consumed by electric utilities. Coverted to Btu by applying national average heat rates for fossil fuel steam electric plants. Data do not include the consumption of wood derived fuel (other than that consumed by the electric utility industry) which amounted to an estimated two quadrillion Btu 1979. This table also excludes small quantities of other energy forms for which consistent historical data are not available, such as solar energy obtained by the use of thermal and photovoltaic collectors; wind energy; and geothermal, biomass, and waste energy other than that consumed at electric utilities.
[8]Less than 0.005 quadrillion Btu.
[9]Preliminary data.

Sources:
1982-1984: U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 1984* (Washington, D.C.: April, 1985).
1952-1981: Various editions of the *Annual Energy Review.*

U.S. Energy Consumption, by Fuel Type, 1952–1984

Year	Total energy consumption Quads[1]	Change from previous year Percent[2]	Coal[3]		Natural gas (dry)		Petroleum[4]		Hydropower[5]	
			Quads[1]	Million short	Quads[1]	Trillion cubic	Quads[1]	Million barrels	Quads[1]	Billion kWh
1952	35.83	–0.8	11.84	454.1	7.55	7.29	14.96	2,661	1.50	112.0
1953	36.76	2.6	11.87	454.8	7.91	7.64	15.56	2,774	1.44	111.6
1954	35.73	–2.8	10.17	389.9	8.33	8.05	15.84	2,831	1.39	114.0
1955	39.17	9.6	11.52	447.0	9.00	8.69	17.25	3,086	1.41	120.3
1956	40.75	4.0	11.72	456.9	9.61	9.29	17.94	3,212	1.49	129.8
1957	40.80	0.1	11.14	434.5	10.19	9.85	17.93	3,215	1.56	137.0
1958	40.65	–0.4	9.83	385.7	10.66	10.30	18.53	3,328	1.63	146.9
1959	42.41	4.3	9.79	385.1	11.72	11.32	19.32	3,477	1.59	144.7
1960	44.08	3.9	10.12	398.1	12.39	11.97	19.92	3,586	1.66	154.0
1961	44.73	1.5	9.89	390.4	12.93	12.49	20.22	3,641	1.68	157.8
1962	46.80	4.6	10.18	402.3	13.73	13.27	21.05	3,796	1.82	172.6
1963	48.61	3.9	10.69	423.5	14.40	13.97	21.70	3,921	1.77	169.1
1964	50.78	4.5	11.25	445.7	15.29	14.81	22.30	4,034	1.91	182.3
1965	52.99	4.4	11.89	472.0	15.77	15.28	23.25	4,202	2.06	196.8
1966	55.99	5.7	12.48	497.7	17.00	16.45	24.40	4,411	2.07	199.0
1967	57.89	3.4	12.24	491.4	17.94	17.39	25.28	4,585	2.34	224.6
1968	61.32	5.9	12.66	509.8	19.21	18.63	26.98	4,902	2.34	225.2

U.S. Energy Consumption, by Fuel Type, 1952–1984—Continued

Year	Total energy consumption Quads[1]	Change from previous year Percent[2]	Coal[3]		Natural gas (dry)		Petroleum[4]		Hydropower[5]	
			Quads[1]	Million short	Quads[1]	Trillion cubic	Quads[1]	Million barrels	Quads[1]	Billion kWh
1969	64.53	5.2	12.72	516.4	20.68	20.06	28.34	5,160	2.66	254.5
1970	66.83	3.6	12.66	523.2	21.79	21.14	29.52	5,364	2.65	252.9
1971	68.30	2.2	12.01	501.6	22.47	21.79	30.56	5,553	2.86	273.1
1972	71.63	4.9	12.45	524.3	22.70	22.10	32.95	5,990	2.94	283.6
1973	74.61	4.2	13.30	562.6	22.51	22.05	34.84	6,317	3.01	289.7
1974	72.76	−2.5	12.88	558.4	21.73	21.22	33.45	6,078	3.31	316.9
1975	70.71	−2.8	12.82	562.6	19.95	19.54	32.73	5,958	3.22	309.3
1976	74.51	5.4	13.73	603.8	20.35	19.95	35.17	6,391	3.07	295.5
1977	76.33	2.4	13.96	625.3	19.93	19.52	37.12	6,727	2.51	241.0
1978	78.18	2.4	13.85	625.2	20.00	19.63	37.97	6,879	3.14	303.2
1979	78.91	0.9	15.11	680.5	20.67	20.24	37.12	6,757	3.14	303.4
1980	75.99	−3.7	15.46	702.7	20.39	19.88	34.20	6,242	3.12	300.1
1981	73.98	−2.6	15.97	732.6	19.93	19.40	31.93	5,861	3.07	295.1
1982	70.84	−4.3	15.32	706.9	18.51	18.00	30.23	5,584	3.56	309.0
1983	70.50	−0.5	15.90	736.7	17.36	16.83	30.05	5,559	3.87	332.0
1984[8]	73.73	4.6	17.20	792.7	18.03	17.48	31.00	5,734	3.78	321.0

Year	Nuclear power		Geothermal		Wood and waste[7]		Net imports of coal coke	
	Quads[1]	Billion kWh	Quads[1]	Billion kWh	Quads[1]	Billion kWh	Quads[1]	Thousand short tons
1952	0	0	0	0	0	0	–0.01	–479
1953	0	0	0	0	0	0	–0.01	–363
1954	0	0	0	0	0	0	–0.01	–272
1955	0	0	0	0	0	0	–0.01	–405
1956	0	0	0	0	0	0	–0.01	–525
1957	0	0	0	0	0	0	–0.02	–704
1958	(7)	0.2	0	0	0	0	–0.01	–271
1959	(7)	0.2	0	0	0	0	–0.01	–337
1960	0.01	0.5	(7)	0	(7)	0.1	–0.01	–227
1961	0.02	1.7	(7)	0.1	(7)	0.1	–0.01	–318
1962	0.03	2.3	(7)	0.1	(7)	0.1	–0.01	–222
1963	0.04	3.2	(7)	0.2	(7)	0.1	–0.01	–298
1964	0.04	3.3	(7)	0.2	(7)	0.1	–0.01	–421
1965	0.04	3.7	(7)	0.2	(7)	0.3	–0.02	–744
1966	0.06	5.5	(7)	0.2	(7)	0.3	–0.03	–1,006
1967	0.09	7.7	0.01	0.3	(7)	0.3	–0.02	–618
1968	0.14	12.5	0.01	0.4	(7)	0.4	–0.02	–698
1969	0.15	13.9	0.01	0.6	(7)	0.3	–0.04	–1,456
1970	0.24	21.8	0.01	0.5	(7)	0.4	–0.06	–2,325
1971	0.41	38.1	0.01	0.5	(7)	0.3	–0.03	–1,335
1972	0.58	54.1	0.03	1.5	(7)	0.3	–0.03	–1,047
1973	0.91	83.5	0.04	2.0	(7)	0.3	–0.01	–317
1974	1.27	114.0	0.05	2.5	(7)	0.3	0.06	2,262

U.S. Energy Consumption, by Fuel Type, 1952–1984—Continued

Year	Nuclear power		Geothermal		Wood and waste[7]		Net imports of coal coke	
	Quads[1]	Billion kWh	Quads[1]	Billion kWh	Quads[1]	Billion kWh	Quads[1]	Thousand short tons
1975	1.90	172.5	0.07	3.2	(7)	0.2	0.01	546
1976	2.11	191.1	0.08	3.6	(7)	0.3	(7)	–4
1977	2.70	250.9	0.08	3.6	0.01	0.5	0.02	588
1978	3.02	276.4	0.06	3.0	(7)	0.3	0.13	5,029
1979	2.71	255.2	0.08	3.9	0.01	0.5	0.07	2,534
1980	2.74	251.1	0.11	5.1	(7)	0.4	–0.04	–1,412
1981	2.97	272.7	0.12	5.7	(7)	0.4	–0.02	–643
1982	3.13	282.8	0.10	4.8	(7)	0.3	–0.02	–873
1983	3.20	293.7	0.13	6.1	(7)	0.4	–0.02	–620
1984[8]	3.55	325.4	0.16	7.7	0.01	0.5	–0.01	–460

Details may not add to totals due to independent rounding.
[1]A quad equals 1 quadrillion Btu. A Btu is the amount of energy required to raise the temperature of 1 pound of water 1 degree Farenheit at or near 39.2 degrees Farenheit.
[2]Percent change calculated from data prior to rounding.
[3]Bituminous coal, lignite, and anthracite.
[4]Refined petroleum products supplied including natural gas plant liquids and crude oil burned as fuel.
[5]Electric utility and industrial generation of hydropower and net electricity imports.
[6]Wood, refuse, and other vegetal fuels consumed by electric utilities. Converted to Btu by applying national average heat rates for fossil fuel steam electric plants. Data do not include the consumption of wood derived fuel (other than that consumed by the electric utility industry) which amounted to an estimated 2 quadrillion Btu in 1979. This total also excludes small quantities of other energy forms for which consistent historical data are not available, such as solar energy obtained by the use of thermal and photovoltaic collectors; wind energy; and geothermal, biomass, and waste energy other than that consumed at electric utilities.
[7]Less than 0.005 quadrillion Btu.
[8]Preliminary data.

Sources:
1982–1984: U.S. Department of Energy, Energy Information Administration, ***Annual Energy Review 1984*** (Washington, D.C.: April, 1985).
1952–1981: Various editions of the Annual Energy Review.

U.S. Energy Consumption, by Sector, 1952–1983[1]
(quadrillion Btu)

	Residential and Commercial		Industrial		Transportation			
	Without Electricity Distributed[2]	With Electricity Distributed[3]	Without Electricity Distributed[4]	With Electricity Distributed[5]	Without Electricity Distributed[2]	With Electricity Distributed[3]	Electric Utilities	Total Energy Consumption
1952	7.05	9.78	14.22	16.99	8.96	9.07	5.60	35.83
1953	6.84	9.73	14.86	17.86	9.07	9.17	6.00	36.76
1954	7.01	10.01	13.81	16.79	8.85	8.93	6.06	35.73
1955	7.47	10.61	15.47	19.00	9.49	9.57	6.75	39.17
1956	7.78	11.17	15.09	19.71	9.80	9.87	7.26	40.75
1957	7.54	11.17	15.89	19.73	9.84	9.90	7.53	40.80
1958	8.04	11.82	15.18	18.82	9.95	10.01	7.48	40.65
1959	8.23	12.32	15.80	19.74	10.30	10.35	8.08	42.41
1960	8.83	13.12	16.50	20.36	10.57	10.60	8.19	44.08
1961	9.03	13.51	16.49	20.45	10.73	10.77	8.47	44.73
1962	9.53	14.34	17.07	21.24	11.18	11.22	9.03	46.80
1963	9.55	14.78	17.81	22.18	11.61	11.65	9.64	48.61
1964	9.65	15.29	18.82	23.50	11.09	11.99	10.34	50.78
1965	10.05	16.09	19.52	24.48	12.39	12.42	11.03	52.99
1966	10.53	17.12	20.41	25.79	13.05	13.08	12.01	55.99
1967	11.09	18.16	20.40	26.01	13.70	13.73	12.71	57.89
1968	11.44	19.29	21.18	27.20	14.81	14.83	13.89	61.32
1969	11.95	20.64	21.94	28.41	15.45	15.48	15.19	64.53

P00000123721

1970	12.18	21.76	22.32	29.00	16.04	16.07	16.28	66.83
1971	12.40	22.64	22.08	28.96	16.66	16.69	17.16	68.30
1972	12.67	23.73	22.78	30.22	17.65	17.68	18.53	71.63
1973	12.31	24.18	23.89	31.84	18.55	18.58	19.84	74.61
1974	11.81	23.76	22.86	30.90	18.06	18.09	20.02	72.76
1975	11.62	23.93	20.56	28.57	18.17	18.21	20.35	70.71
1976	12.27	25.04	21.63	30.40	19.03	19.07	21.57	74.51
1977	11.89	25.39	21.99	31.15	19.75	19.79	22.69	76.33
1978	11.93	26.11	21.98	31.49	20.54	20.57	23.72	78.18
1979	11.55	25.80	22.87	32.65	20.42	20.46	24.07	78.91
1980	10.73	25.66	21.11	30.64	19.65	19.69	24.50	75.99
1981	10.06	25.22	19.79	29.28	19.45	19.48	24.68	73.98
1982	10.07	25.63	17.45	26.14	19.03	19.07	24.26	70.84
1983	9.54	25.44	16.88	25.91	19.11	19.15	24.93	70.50
1984[6]	9.57	25.98	18.24	27.88	19.83	19.86	26.05	73.73

Details may not add to totals due to independent rounding.

[1]Data do not include consumption of wood derived fuel (other than that consumed by the electric utility industry) which amounted to an estimated 2.2 quadrillion Btu in 1981. Also, small quantities of other energy forms for which consistent historical data are not available, such as solar energy obtained by the use of thermal and photovoltaic collectors; wind energy; and geothermal, biomass, and waste energy other than that consumed at electric utilities, are not included.

[2]Includes only those fossil fuels consumed directly in the sector.

[3]Includes those fossil fuels consumed directly in the sector, electricity sales to the sector, and energy losses in the conversion and transmission of electricity. Conversion and transmission losses are allocated to sectors in proportion to electricity sales to sectors.

[4]Includes those fossil fuels and very small quantities of self-produced hydropower consumed directly in the sector.

[5]Includes those fossil fuels and very small quantities of self-produced hydropower consumed directly in the sector, electricity sales to the sector, and energy losses in the conversion and transmission of electricity. Conversion and transmission losses are allocated to sectors in proportion to electricity sales to sectors.

[6]Preliminary data.

Sources:

1982–1984: U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 1984* (Washington, D.C.: April, 1985).

1952–1981: Various editions of the Annual Energy Review.

Residential Heating Equipment and Fuels, 1950–1980

Item	Millions 1950	Millions 1960	Millions 1970	Millions 1980[5]	Percent 1950	Percent 1960	Percent 1970	Percent 1980
Occupied units, total	42.826	53.024	63.445	80.390	100.0	100.0	100.0	100.0
Residential heating equipment:								
Warm air furnace	11.508[1]	17.378	27.515	39.279	26.9	32.8	43.4	48.9
Steam or hot water	10.071	11.990	13.211	13.859	23.5	22.6	20.8	17.2
Floor, wall, or pipeless furnace	(1)	6.088	5.552	4.693	(1)	11.5	8.8	5.8
Built-in electric units	0	.664	3.236	6.370	0	1.3	5.1	7.9
Room heaters with flue	15.399[2]	11.183[2]	7.209	6.098	36.0	21.1	11.4	7.6
Room heaters without flue	5.268	5.218	3.558	2.736	12.3	9.8	5.6	3.4
Fireplaces, stoves, or heaters[3]	(2)	(2)	2.766	5.152	(2)	(2)	4.4	4.9
None	.581	.503	.398	.677	1.4	.9	.6	.7
House heating fuel:								
Utility gas	11.387	22.851	35.014	42.658	26.6	43.1	55.2	53.1
Fuel oil, kerosene, etc.	9.686	17.158	16.473	14.655	22.6	32.4	26.0	18.2
Electricity	.283	.933	4.876	14.768	.7	1.8	7.7	18.3
Bottled, tank, or LP gas	.787	2.686	3.807	4.535	1.8	5.1	6.0	5.6
Wood and other fuel	4.855	2.460	1.060	2.729	11.3	4.6	1.7	3.4
Coal and coke	14.828	6.456	1.821	.504	34.6	12.2	2.9	.6
None	.999	.478	.395	.541	2.3	.9	.6	.7

Residential Heating Equipment and Fuels, 1950–1980—Continued

Table A-56
Energy

Item	Millions 1950	Millions 1960	Millions 1970	Millions 1980[5]	Percent 1950	Percent 1960	Percent 1970	Percent 1980
Cooking fuel:								
Electricity	6.403	16.351	25.768	41.906	15.0	30.8	40.6	52.1
Utility gas	22.094	27.296	31.244	32.375	51.6	51.5	49.2	40.3
Bottled, tank, or LP gas	3.417	6.491	5.314	5.569	8.0	12.2	8.4	6.9
Other fuel	10.796	2.603	.908	.398	25.2	4.9	1.4	.5
None	.124	.280	.213	.142	.3	.5	.3	.2

[1] "Floor, wall, or pipeless furnace" included in "Warm air furnace."
[2] "Fireplaces, stoves, or portable heaters" included in "Room heaters with flue."
[3] Portable heaters.
[4] Based on year round housing units (86.8 million); therefore data for 1980 residential heating equipment will not add to total.
[5] 1981 data available through Annual Housing Survey, 1981, Bureau of Census; 1981 total occupied units 83,175,000.

Source: U.S. Bureau of the Census, *Statistical Abstract of the United States:* 1985 (Washington, D.C.: 1985), Table 1319.

Vehicle Travel by Mode, Selected Years, 1970–1982
(million miles)

Year	Passenger cars	Trucks	Buses	Total highway[1]	Air	Rail[2]	Total vehicle travel: Miles (million)	Total vehicle travel: Kilometers (billion)	Vehicles miles traveled per household	Average transportation energy use per unit of vehicle travel: Btu per mile	Average transportation energy use per unit of vehicle travel: Mega joules per km
1970	890,844	214,670	5,043	1,120,705	5,842	31,436	1,157,983	1,863	18,260	11,660	7,645
1973	1,016,861	267,147	4,960	1,308,562	6,227	32,605	1,347,394	2,168	19,640	11,970	7,850
1974	990,721	267,519	5,060	1,285,647	6,203	32,135	1,323,985	2,130	18,820	11,560	7,580
1975	1,028,121	274,454	5,148	1,330,074	6,245	28,960	1,365,279	2,197	18,940	11,430	7,490
1976	1,075,762	307,950	5,761	1,411,890	6,555	29,862	1,448,307	2,330	19,620	11,440	7,500
1977	1,118,649	329,465	5,887	1,476,567	6,993	30,017	1,513,577	2,435	20,030	11,330	7,430
1978	1,171,092	347,906	6,076	1,548,213	7,664	30,213	1,586,090	2,552	20,520	11,290	7,400
1979	1,140,518	360,500	6,105	1,529,133	8,393	30,662	1,568,188	2,523	19,840	11,300	7,410
1980	1,111,887	384,570	6,400	1,520,857	8,130	30,503	1,559,490	2,509	19,310	10,760	7,060
1981	1,114,330	411,526	6,415	1,550,271	NA	NA	NA	NA	NA	NA	NA
1982	1,133,883	436,959	6,639	1,592,481	8,002	NA	NA	NA	NA	NA	NA
Average annual percentage change											
1973–76	0.6	1.4	1.9	0.8	0.1	–5.8	0.7	0.7	–1.8	–2.3	–2.3
1975–78	4.4	8.2	5.7	5.2	7.1	1.4	5.1	5.1	2.7	–0.4	–0.4
1978–80	–2.6	5.1	2.6	–0.9	3.0	0.5	–0.8	–0.8	–3.0	–2.4	–2.4

[1]Includes motorcycles, not shown separately.
[2]Car-miles.

Sources:
Passenger cars, trucks, buses, and motorcycles: U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics*, Washington, D.C., annual, Table VM–1.

P00000123725

Vehicle Travel by Mode, Selected Years, 1970–1982—Continued
(million miles)

Year	Passenger cars	Trucks	Buses	Total highway[1]	Air	Rail[2]	Total vehicle travel: Miles (million)	Total vehicle travel: Kilometers (billion)	Vehicles miles traveled per household	Average transportation energy use per unit of vehicle travel: Btu per mile	Average transportation energy use per unit of vehicle travel: Mega joules per km

Air: Sum of vehicle miles traveled for air carriers and general aviation. Air carriers: Civil Aeronautics Board, *Air Carrier Traffic Statistics,* Washington, D.C., monthly. General aviation: National Transportation Safety Board, Information Systems Division (TE-50).

Rail: Sum of vehicle miles traveled for Class 1 railroads and rail transit. Class 1 railroads: Association of American Railroads, *Statistics of Railroads of Class 1. Years 1970–80,* Washington, D.C., 1982. Rail transit: American Public Transit Association, Transit Fact Book 1981, Washington, D.C., 1981.

Households, 1970, 1980: U.S. Department of Commerce, Bureau of the Census, Current Population Reports, "Population Characteristics," Series P-20, No. 367. Number of households for intervening years derived using linear interpolation. At the time of writing, the Census Bureau had not revised its historical estimates of number of households to be consistent with data from the 1980 Decennial Census.

Transportation energy use per unit of travel: Sum of energy used by highway, air, and rail modes divided by total travel.

Principal Means of Transportation to Work, 1960–1980
(million workers -- percent of workers)

Year	Total number of workers	Private auto	Carpool	Public transportation	Walk, other
1960	61.9	41.4 (67%)[1]	([1])	7.8 (13%)	12.7 (21%)
1970	76.9	50.7 (66%)	9.0 (12%)	6.5 (8%)	10.6 (14%)
1974	50.6	35.0 (69%)	7.2 (14%)	3.0 (6%)	5.1 (10%)
1975	49.3	33.8 (69%)	8.4 (17%)	2.7 (5%)	4.2 (8%)
1976	50.3	35.7 (71%)	7.8 (15%)	2.7 (6%)	4.0 (8%)
1977	51.7	36.6 (71%)	8.4 (16%)	2.8 (6%)	3.8 (7%)
1978	53.4	38.2 (72%)	8.0 (15%)	3.1 (6%)	3.9 (7%)
1980	96.5	62.3 (65%)	19.1 (20%)	6.1 (6%)	9.1 (9%)
1978, by location					
In SMSAs, total	37.1	26.8 (72%)	5.0 (14%)	3.0 (8%)	2.2 (6%)
In central cities	15.3	10.0 (66%)	1.9 (13%)	2.2 (14%)	1.1 (7%)
Outside central cities	21.8	16.8 (77%)	3.1 (14%)	0.8 (4%)	1.0 (5%)
Outside SMSAs	16.3	11.4 (70%)	3.0 (18%)	0.1 (1%)	1.7 (11%)

Data are not strictly comparable; data for 1960 and 1970 include all workers 14 years old and older; data for 1980 include all workers 16 years old and older; 1974–1978 include heads of household only.

[1] "Carpool" included in "private auto" in 1960.

Sources:
1960: U.S. Bureau of the Census, *Census of Population: 1960, Volume 1, Characteristics of the Population, Part 1: United States Summary* (Washington: USGPO, 1964), Table 94;
1970: U.S. Bureau of the Census, *Census of Population: 1970, Volume 1, Characteristics of the Population, Part 1: United States Summary* (Washington: USGPO, 1973), Table 87;
1974–1977: U.S. Bureau of the Census, *Annual Housing Survey: 1977* (Washington: USGPO, 1979), Part A, p.6, and previous annual issues;
1978: U.S. Bureau of the Census, *Annual Housing Survey: 1978* (Washington: USGPO, 1981), Part F, p.9.;
1980: U.S. Bureau of the Census, *Census of Population and Housing*, Supplementary, Report Series, PHC, 80–S1–1 (Washington USGPO), p. 14.

U.S. Energy Consumption, by Mode of Transportation, 1970–1981
(trillion Btu)

Year	Personal passenger vehicle[1]	Buses	Light trucks	Other trucks	Total highway	Total Air	Water	Pipe-line	Rail	Total energy
1970	8,223.0	110.2	1,357.7	1,927.2	11,618.1	1,311.6	835.7	994.3	574.9	15,334.6
1973	9,751.4	110.3	1,567.2	2,670.7	14,099.6	1,378.9	905.3	994.0	651.9	18,029.7
1974	9,336.4	113.8	1,495.1	2,453.3	13,398.6	1,254.7	888.2	932.3	656.7	17,130.5
1975	9,557.5	119.8	2,123.3	1,932.8	13,733.3	1,273.6	933.8	838.0	595.9	17,374.6
1976	9,912.3	129.3	2,609.0	1,934.9	14,585.5	1,358.9	1,083.7	800.4	617.3	18,445.8
1977	10,085.1	132.9	2,815.9	2,054.2	15,088.1	1,438.1	1,205.3	784.0	627.3	19,142.8
1978	10,473.5	136.2	2,777.9	2,394.1	15,781.7	1,494.9	1,410.2	781.1	627.7	20,095.6
1979	10,032.7	134.6	2,937.6	2,340.4	15,445.3	1,595.1	1,632.0	856.1	674.2	20,202.7
1980	9,208.4	138.0	2,678.0	2,525.6	14,550.0	1,565.0	1,715.1	892.2	666.9	19,389.2
1981	9,004.6	139.7	2,813.9	2,564.8	14,523.0	1,493.8	1,561.7	901.8	626.6	19,106.9

These ORNL estimates are based on U.S. sales of transportation fuels and exclude military consumption. See source for methods used in estimating transportation energy use.

[1]Includes passenger cars, motorcycles, and recreational vehicles.

Source: Oak Ridge National Laboratory, *Transportation Energy Data Book, Edition* 7 (Washington, D.C.: 1984), ORNL-6050.

Nuclear Power Plant Capacity and Electricity Production, 1957–1983

Table A-60
Energy

Year	Yearend operating reactors[1]	Yearend capacity (million) killowatt)	Electricity generation Billion net kilowatt hours	Electricity generation Percent of total U.S. generation
1957	1	0.1	([2])	([3])
1958	1	0.1	0.2	([3])
1959	1	0.1	0.2	([3])
1960	2	0.3	0.5	0.1
1961	3	0.4	1.7	0.2
1962	4	0.7	2.3	0.3
1963	7	0.7	3.2	0.4
1964	9	0.9	3.3	0.3
1965	10	0.9	3.7	0.4
1966	11	1.9	5.5	0.5
1967	10	2.9	7.7	0.6
1968	10	2.8	12.5	0.9
1969	13	4.0	13.9	1.0
1970	19	6.5	21.8	1.4
1971	21	8.7	38.1	2.4
1972	29	15.3	54.1	3.1
1973	39	22.9	83.5	4.5
1974	48	31.7	114.0	6.1
1975	54	33.3	172.5	9.0
1976	60	43.3	191.1	9.4
1977	65	46.0	250.9	11.8
1978	70	49.6	276.4	12.5
1979	68	49.3	255.2	11.4
1980	70	51.1	251.1	11.0
1981	74	55.5	272.7	11.9
1982	77	59.6	282.7	12.6
1983	80	62.8	293.7	12.7
1984[4]	86	69.5	325.2	13.5

[1]Operating reactors and capacity: Prior to 1973, the number of "yearend operating reactors" includes reactors that were in commercial operation by December 31 of the stated year. Units decommissioned or inoperative for extended periods were generally included. For 1973 and forward, the number of reactors includes units issued low-power operating licenses and generally does not include units in long-term shutdown status. Prior to 1973, "yearend operating capacity" figures are gross kilowatts of installed capacity. For 1973 and forward, the capacity is net Maximum Dependable Capacity (MDC), except for some units in startup testing for which the Design Electrical Rating (DER) value is used.

[2]Less than 0.05 billion kilowatt-hours

[3]Less than 0.05 percent

[4]Preliminary

Sources: U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 1984* (Washington, D.C.: April, 1985), p. 193.

International Production of Crude Oil,[1] 1960–1983
(million barrels per day)

Year	China	Indonesia	Iran	Iraq	Kuwait[2]	Libya	Mexico	Nigeria
1960	0.10	0.41	1.07	0.97	1.69	(3)	0.27	0.02
1961	0.11	0.42	1.20	1.01	1.74	0.02	0.29	0.05
1962	0.12	0.45	1.34	1.01	1.96	0.18	0.31	0.07
1963	0.13	0.44	1.49	1.16	2.10	0.44	0.32	0.08
1964	0.18	0.46	1.71	1.26	2.30	0.86	0.32	0.12
1965	0.23	0.48	1.91	1.31	2.36	1.22	0.32	0.27
1966	0.29	0.47	2.13	1.39	2.48	1.50	0.33	0.42
1967	0.28	0.51	2.60	1.23	2.50	1.74	0.37	0.32
1968	0.30	0.60	2.84	1.50	2.61	2.60	0.39	0.14
1969	0.48	0.75	3.38	1.52	2.77	3.11	0.46	0.54
1970	0.60	0.85	3.83	1.55	2.99	3.32	0.49	1.08
1971	0.78	0.89	4.54	1.69	3.20	2.76	0.49	1.53
1972	0.90	1.08	5.02	1.47	3.28	2.24	0.51	1.82
1973	1.09	1.34	5.86	2.02	3.02	2.18	0.47	2.05
1974	1.32	1.38	6.02	1.97	2.55	1.52	0.57	2.26
1975	1.49	1.31	5.35	2.26	2.08	1.48	0.71	1.78
1976	1.67	1.50	5.88	2.42	2.15	1.93	0.83	2.07
1977	1.87	1.69	5.66	2.35	1.97	2.06	0.98	2.09
1978	2.08	1.64	5.24	2.56	2.13	1.98	1.21	1.90
1979	2.12	1.59	3.17	3.48	2.50	2.09	1.46	2.30
1980	2.11	1.58	1.66	2.51	1.66	1.79	1.94	2.06
1981	2.01	1.61	1.38	1.00	1.13	1.14	2.31	1.43
1982	2.05	1.34	2.21	1.01	.82	1.04	2.75	1.30
1983	2.12	1.39	2.43	NA	NA	1.08	2.69	1.24
1984[5]	2.21	1.47	2.19	NA	NA	NA	2.76	1.37

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International Production of Crude Oil,[1] 1960-1983—Continued
(million barrels per day)

Year	Saudi Arabia[2]	United Kingdom	United States	USSR	Venezuela	Other	Total OPEC[4]	Total World
1960	1.31	(3)	7.04	2.91	2.85	2.32	8.70	20.96
1961	1.48	(3)	7.18	3.28	2.92	2.73	9.36	22.43
1962	1.64	(3)	7.33	3.67	3.20	3.04	10.51	24.32
1963	1.79	(3)	7.54	4.07	3.25	3.32	11.51	26.13
1964	1.90	(3)	7.61	4.60	3.39	3.65	12.98	28.30
1965	2.21	(3)	7.80	4.79	3.47	3.92	14.34	30.30
1966	2.60	(3)	8.30	5.23	3.37	4.41	15.77	32.93
1967	2.81	(3)	8.81	5.68	3.54	4.99	16.85	35.37
1968	3.04	(3)	9.10	6.08	3.61	5.82	18.79	38.64
1969	3.22	(3)	9.24	6.48	3.59	6.21	20.91	41.69
1970	3.80	(3)	9.64	6.97	3.71	6.46	23.41	45.29
1971	4.77	(3)	9.46	7.44	3.55	6.73	25.33	47.84
1972	6.02	(3)	9.44	7.88	3.22	7.37	27.09	50.26
1973	7.60	(3)	9.21	8.47	3.37	8.99	30.99	55.67
1974	8.48	(3)	8.77	9.00	2.98	9.03	30.73	55.85
1975	7.08	0.01	8.38	9.63	2.35	8.97	27.16	52.88
1976	8.58	0.25	8.13	10.14	2.29	9.47	30.74	57.31
1977	9.25	0.77	8.25	10.68	2.24	9.83	31.30	59.69
1978	8.30	1.08	8.71	11.19	2.17	9.86	29.81	60.06
1979	9.53	1.57	8.55	11.46	2.36	10.36	30.93	62.54
1980	9.90	1.62	8.60	11.77	2.17	10.17	26.89	59.54
1981	9.82	1.81	8.57	11.91	2.10	9.57	22.65	55.90
1982	6.48	2.07	8.65	12.08	1.90	9.31	18.87	53.46
1983	5.09	2.29	8.69	12.03	1.77	NA	17.56	52.98
1984[5]	4.67	2.50	8.76	11.83	1.80	NA	17.46	53.72

Sum of components may not equal total due to independent rounding.
[1]Includes lease condensate; excludes natural gas plant liquids.
[2]Kuwait and Saudi Arabia each include one-half of the production in the Partitioned Zone (formerly Neutral Zone).
[3]Less than 5,000 barrels per day.
[4]Organization of Petroleum Exporting Countries.
[5]Preliminary
NA - Not Available.

Source: U.S. Department of Energy, Energy Information Administration, *Annual Energy Review 1984* (Washington, D.C.: April 1985), p. 221.

Selected Energy Producing and Consuming Indicators, 1960–1983

Year	Total housing units[1] (millions)	Operating refineries[2] Number	Operating refineries[2] Capacity (million barrels per day)	Producing oil wells[3] Number (thousand)	Producing oil wells[3] Production per well (barrels per day)	Producing gas wells[3] Number (thousand)
1960	58.33	290	9.54	591	12.0	91
1961	NA	289	9.63	595	12.1	97
1962	NA	287	9.79	596	12.3	100
1963	NA	287	9.81	589	12.7	103
1964	NA	282	10.06	588	12.9	103
1965	NA	273	10.16	589	13.3	112
1966	NA	267	10.17	583	14.2	112
1967	NA	260	10.41	565	15.3	112
1968	NA	270	11.17	554	16.2	114
1969	NA	264	11.58	542	16.9	114
1970	68.67	262	11.88	531	18.0	117
1971	NA	253	12.66	517	18.1	120
1972	NA	250	13.03	508	18.4	121
1973	75.97	252	13.45	497	18.3	124
1974	77.60	257	14.22	498	17.6	128
1975	79.09	262	14.70	500	16.8	132
1976	80.88	265	14.87	499	16.3	138
1977	82.42	273	15.86	507	16.4	148

Selected Energy Producing and Consuming Indicators, 1960–1983—Continued

Year	Total housing units[1] (millions)	Operating refineries[2]		Producing oil wells[3]		Producing gas wells[3]
		Number	Capacity (million barrels per day)	Number (thousand)	Production per well (barrels per day)	Number (thousand)
1978	84.62	290	16.79	517	17.0	157
1979	86.37	301	17.15	531	16.3	170
1980	88.21	311	17.56	548	15.9	182
1981	91.56	315	18.05	557	15.4	190
1982	NA	301	17.89	580	14.9	204
1983	NA	258	16.86	NA	NA	NA

Selected Energy Producing and Consuming Indicators, 1960–1983—Continued

Year	Motor vehicle registration (million)	Population[4] (million)	Annual per capita energy consumption (million Btu)	Gross National Product implicit price deflator (1972 = 100)
1960	74.4	180.0	245	68.70
1961	76.6	183.0	244	69.33
1962	79.8	185.8	252	70.61
1963	83.5	188.5	258	71.67
1964	87.3	191.1	266	72.77
1965	91.7	193.5	274	74.36
1966	95.7	195.6	286	76.76
1967	98.9	197.5	293	79.06
1968	103.0	199.4	308	82.54
1969	107.4	201.4	320	86.79
1970	111.2	204.0	328	91.45
1971	116.3	206.8	330	96.01
1972	122.6	209.3	342	100.00
1973	130.0	211.4	353	105.75
1974	134.9	213.3	341	115.08
1975	137.9	215.5	328	125.79
1976	143.5	217.6	342	132.34
1977	148.8	219.8	347	140.05
1978	153.9	222.1	352	150.42
1979	159.6	224.6	351	163.42

1980	161.6	227.2	335	178.64
1981	164.3	229.3	323	195.14
1982	165.2	231.5[5]	307	206.88
1983	167.2	234.0	301	NA

NA - Not available.
[1]Includes mobile homes, individual units in apartment buildings, and unoccupied units.
[2]Data are for operating and operable shutdown refineries in the United States, including the Hawaiian Foreign Trade Zone, as of January 1.
[3]As of December 31.
[4]Resident population of the 50 states and the District of Columbia estimated for July 1 of each year.
[5]Preliminary.

Sources:
Housing units: 1960 and 1970: Bureau of the Census, Census of Population and Housing; 1973–1981: Bureau of the Census, *Annual Housing Survey.*
Operating refineries: 1960–1977: Bureau of Mines, Mineral Industry Surveys, *Petroleum Refineries, Annual:* 1978–1981: Energy Information Administration, Energy Data Reports, *Petroleum Refineries in the United States and U.S. Territories;* 1983: Energy Information Administration, *Petroleum Supply Annual.*
Producing oil wells: 1960–1975: Bureau of Mines, Mineral Industry Surveys, *Petroleum Statement, Annual;* 1976–1980: Energy Information Administration, Energy Data Reports, *Petroleum Statement, Annual;* 1981–1982: Independent Petroleum Association of America, *The Oil Producing Industry in Your State,* Petroleum Independent Publishing, Inc., 1982, 1983.
Producing gas wells: 1960–1975: Bureau of Mines, Mineral Industry Surveys, *Natural Gas, Annual;* 1976–1982: Energy Information Administration, Energy Data Reports, *Natural Gas, Annual.*
Motor vehicle registration: 1960–1975: Federal Highway Administration, *Highway Statistics Summary to 1975;* 1976–1983: Federal Highway Administration, *Highway Statistics, Annual.*
Population: 1960–1980: Bureau of the Census, *Current Population Reports,* "Population Estimates and Projections," Series P-25; 1981–1982: Bureau of the Census, "Estimates of the Population of the United States to June 1, 1984 (Washington: USGPO, 1984).
Annual per capita energy consumption: U.S. Department of Energy, Energy Information Administration, 1981 Annual Report to Congress; 1981–1983: *State Energy Data Supplement.*
Gross National Product implicit price deflation: 1960–1976: U.S. Department of Commerce, Bureau of Economic Analysis, *The National Income and Product Accounts of the United States; 1929–1976: Statistical Tables;* 1977–1982: U.S. Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business,* monthly.

Table A-63
International

Pesticide Production,[1] by Type, 1950–1983
(million pounds)

Year	Synthetic organic pesticides: Total	Herbicides	Insecticides[2]	Fungicides	Year	Synthetic organic pesticides: Total	Herbicides	Insecticides[2]	Fungicides
1950	286	NA	NA	NA	1969	1,104	393	571	141
1951	464	49	319	96	1970	1,034	404	490	140
1955	506	NA	NA	129	1971	1,136	429	558	149
1960	648	102	366	179	1972	1,158	451	564	143
1961	700	121	411	168	1973	1,289	496	639	154
1962	730	151	461	117	1974	1,417	604	650	163
1963	763	175	478	111	1975	1,603	788	660	155
1964	783	226	444	113	1976	1,364	656	566	142
1965	877	263	490	124	1977	1,388	674	570	143
1966	1,013	324	552	137	1978	1,416	664	605	148
1967	1,050	409	496	144	1979	1,429	657	617	155
1968	1,192	469	569	154	1980	1,468	806	506	156
					1981	1,430	839	448	143
					1982	1,113	623	379	111
					1983	1,021	570	324	127

Details may not add to total due to independent rounding.
NA - Not available.
[1]Production data include the total quantity of a commodity made available by the original manufacturers only. Production excludes intermediate products in the manufacturing process.
[2]Insecticides include fumigants, rodenticides, and soil conditioners.

Source: U.S. International Trade Commission, *Synthetic Organic Chemicals, United States Production and Sales, 1983* (Washington, D.C.: 1984), and previous annual issues.

World Chlorofluorocarbon Production and Release, 1971–1983[1]
(millions of pounds)

Year	Annual Production	Annual Released	Cumulative Released	Year	Annual Production	Annual Released	Cumulative Released
1931	0.0	0.1	0.1	1975	695.1	715.0	7,355.7
1940	4.7	2.4	7.6	1976	750.5	707.1	8,062.7
1950	41.2	35.0	157.5	1977	703.3	675.1	8,737.9
1960	149.1	129.6	946.9	1978	681.0	624.9	9,362.8
1970	559.2	506.5	4,066.5	1979	646.7	601.2	9,963.8
1971	604.8	548.7	4,615.1	1980	639.8	583.3	10,547.2
1972	686.8	605.7	5,220.8	1981	638.2	588.9	11,136.1
1973	772.4	679.7	5,900.5	1982	599.4	576.6	11,712.7
1974	812.5	740.0	6,640.5	1983	644.1	596.0	12,308.7

Data are total of compounds F-11 and F-12, which are about 94 percent of the chlorofluoromethanes produced.
Chlorofluoromethanes are a group of carbon compounds. Data is available from the Chemical Manufacturers Association which presents F-11 and F-12 separately.
Data are composed of reports from 19 companies supporting the Chemical Manufacturers Association's Fluorocarbon Research Program and from estimates of production from nonreporting countries.
[1] U.S.S.R., Eastern Europe, and The Peoples' Republic of China have been excluded from the data base.

Source: Chemical Manufactueters Association, *Production, Sales, and Calculated Release of CFC#11 and CFC-12 through 1982* (Washington, D.C.: 1984).

Carbon Dioxide Concentrations in Air, 1958–1985[1]
(parts per million)

Year	Mauna Loa Hawaii	South Pole Antarctica	Year	Mauna Loa Hawaii	South Pole Antarctica	Year	Mauna Loa Hawaii	South Pole Antarctica
1958	NA	315	1970	325	324	1982	341	339
1959	316	316	1971	326	325	1983	342	340
1960	317	316	1972	327	326	1984	344	342
1961	317	317	1973	329	327	1985	345	343
1962	318	318	1974	330	328			
1963	319	318	1975	331	329			
1964	319	319	1976	332	330			
1965	320	319	1977	334	332			
1966	321	320	1978	335	333			
1967	321	321	1979	337	335			
1968	322	322	1980	338	337			
1969	324	322	1981	339	338			

[1]Concentrations measured annually on January 1.
NA - Not Available.

Sources:
1958–1980: R.B. Bacastow and C.D. Keeling, "Atmospheric Carbon-Dioxide Concentration, the Observed Airborne Fraction, the Fossile Fuel Airborne Fraction, and the Difference in Hemispheric Airborne Fractions," in *Scope 16: Globel Carbon Modelling*, B. Bolin, ed. (London: John Wiley and Sons, 1981);
1981–1985: Private communication with Dr. C.D.Keeling, Scripps Institute of Oceanography, LaJolla, California.

Whale Abundance and Catch, by Species, 1920–1984

Whale abundance	Blue	Humpback	Fin	Sei	Sperm	Gray	Minke	Total
Virgin stock (thousands)	215	50	448	200	922	11	361	220
1970s stock (thousands)	13	7	101	76	641	11	325	1,174
Percent of virgin stock remaining	6	14	22	38	69	100	90	53
World catch, by year								
1920	2,274	545	4,946	1,120	749	NA	NA	9,634
1925	7,548	3,342	9,121	1,093	1,439	NA	NA	22,543
1930	19,079	1,919	14,281	841	1,126	NA	NA	37,246
1935	16,834	4,088	14,078	962	2,238	NA	NA	38,200
1940	11,559	528	19,924	541	4,091	NA	NA	36,643
1945	1,111	303	2,653	218	1,661	NA	NA	5,946
1950	6,313	5,063	22,902	2,471	8,183	NA	NA	44,932
1955	2,495	2,713	32,185	1,940	15,594	NA	NA	54,927
1960	1,465	3,576	31,064	7,035	20,344	NA	NA	63,484
1965	613	452	12,351	25,454	25,548	NA	NA	64,418
1970	0	0	5,057	11,195	25,842	NA	4,539	46,633
1975	0	17	1,634	4,975	21,045	NA	11,221	38,892
1976	0	11	785	1,866	17,134	NA	10,176	29,972
1977	0	14	155	2,179	12,279	NA	12,398	27,025
1978	0	32	650	634	10,274	NA	9,018	20,608
1979	0	19	743	150	8,536	NA	9,900	20,449[1]
1980	0	16	472	102	2,091	NA	11,709	15,129[1]
1984	0	8	289	100	463	179	6,222	7,808[1]

Whale Abundance and Catch, by Species, 1920–1984—Continued

Table A–66
International

Whale abundance	Blue	Humpback	Fin	Sei	Sperm	Gray	Minke	Total

NA - Not available.
[1]Total is greater than the sum of species listed individually; Brydes and others were omitted from the table.

Sources:
Whale abundance: Victor B. Scheffer, "The Status of Whales," Pacific Discovery 29(1):3 (1979).
Whale catch, 1920–1970, except minke: William E. Schevill, ed., *The Whale Problem: A Status Report* (Cambridge, Mass.: Harvard University Press, 1974), Table 13–1, pp. 306–307. *1971–1978, except minke:* Committee for Whaling Statistics, International Whaling Statistics (Sandefjord, Norway,1979), LXXXIII, Table b, p. 12. *1970–1978,* minke:—, LXXXIII, Table Z2, p. 27, *International Whaling Statistics LXXXVIII and LXXXIII,* Ed. by Committee for Whaling Statistics, Sandefjord, Norway, 1981.
1984: International Whaling Commission 1984 schedule plus additional known catches.

World Commercial Fish Catch, 1951–1983
(million metric tons)[1]

Year	Fresh Water	Marine: Peruvian anchovy	Marine: Other[2]	Marine: Total Marine	Total
1951	2.6	NA	20.9	20.9	23.5
1952	2.8	NA	22.3	22.3	25.1
1953	3.0	NA	22.9	22.9	25.9
1954	3.2	NA	24.4	24.4	27.6
1955	3.4	NA	25.5	25.5	28.9
1956	3.5	.1	27.2	27.3	30.8
1957	3.9	.3	27.5	27.8	31.7
1958	4.5	.8	28.0	28.8	33.3
1959	5.1	2.0	29.8	31.8	36.9
1960	5.6	3.5	31.1	34.6	40.2
1961	5.7	5.3	32.6	37.9	43.6
1962	5.8	7.1	31.9	39.0	44.8
1963	5.9	7.2	33.5	40.7	46.6
1964	6.2	9.8	35.9	45.7	51.9
1965	7.0	7.7	38.5	46.2	53.2
1966	7.3	9.6	40.4	50.0	57.3
1967	7.2	10.5	42.7	53.2	60.4
1968	7.4	11.3	45.2	56.5	63.9
1969	7.6	9.7	45.4	55.1	62.7
1970	8.4	13.1	46.6	59.7	68.1
1971	9.0	11.2	48.3	59.5	68.5
1972	5.7	4.8	53.7	58.5	64.2
1973	5.8	1.7	55.3	57.0	62.8
1974	5.8	4.0	56.8	60.7	66.5
1975	6.2	3.3	57.0	60.2	66.4
1976	5.9	4.3	59.7	63.9	69.8
1977	6.1	.8	62.3	62.8	68.9
1978	5.8	1.4	63.3	64.6	70.4
1979	5.9	1.4	63.8	65.2	71.1
1980	6.2	.8	65.4	65.8	72.0
1981	6.6	1.5	66.7	68.2	74.8
1982	6.8	1.8	67.9	69.7	76.5
1983	7.2	.1	69.2	69.3	76.5

NA - Not available.
[1]There are 2,204.6 pounds in a metric ton.
[2]Includes diadromous (salmon and other anadromous fishes and catadromous fishes such as eels).

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, *Fisheries of the United States, 1984* (Washington, D.C.: April 1985).

World Population and Growth Rates by Region: Selected Years, 1950–2000

Table A–68
International

Year	World	Total Asia	South Asia	East Asia	Europe	USSR	Africa	Latin America	North America	Oceania
Population in billions										
1950	2.54	1.40	0.72	0.67	0.39	0.18	0.22	0.17	0.17	0.012
1960	3.06	1.71	0.89	0.82	0.43	0.21	0.28	0.22	0.20	0.016
1970	3.72	2.13	1.12	1.01	0.46	0.24	0.36	0.29	0.23	0.019
1980	4.48	2.62	1.40	1.21	0.48	0.27	0.47	0.36	0.25	0.023
1983	4.72	2.77	1.51	1.27	0.49	0.27	0.52	0.39	0.26	0.024
1985	4.89	2.88	1.58	1.30	0.49	0.28	0.55	0.41	0.26	0.024
1990	5.32	3.15	1.77	1.37	0.50	0.29	0.64	0.46	0.28	0.026
2000	6.25	3.71	2.17	1.54	0.51	0.30	0.85	0.56	0.30	0.029
Average annual rate of growth (in percent)										
1950–1955	1.8	2.0	2.0	2.0	0.8	1.7	2.2	2.6	1.8	2.3
1955–1960	1.9	2.1	2.2	2.0	0.8	1.8	2.3	2.8	1.8	2.2
1960–1965	1.8	1.9	2.3	1.5	0.9	1.5	2.5	2.8	1.5	2.1
1965–1970	2.1	2.4	2.3	2.6	0.7	1.0	2.6	2.7	1.1	2.1
1970–1975	2.0	2.3	2.3	2.2	0.6	0.9	2.7	2.5	1.1	1.9
1975–1980	1.7	1.9	2.3	1.4	0.4	0.9	2.8	2.3	1.1	1.3
1980–1983	1.8	1.9	2.3	1.4	0.3	0.8	3.0	2.3	1.0	1.6

Source: Department of Commerce, U.S. Bureau of the Census, *World Population 1983: Recent Demographic Estimates for Countries and Regions of the World,* forthcoming and unpublished data.

P00000123742

Environmental Impact Statements Filed by Agency, 1978–1984[1]

Table A-69
NEPA

Agency	1978	1979	1980	1981	1982	1983	1984
U.S. Department of Agriculture	225	172	104	102	89	59	65
U.S. Department of Commerce	56	54	53	36	25	14	24
U.S. Department of Defense	—	1	1	1	1	1	0
Air Force	5	8	3	7	4	6	5
Army	16	40	9	14	3	6	5
U.S. Army Corps of Engineers	182	182	150	186	127	119	116
Navy	6	11	9	10	6	4	9
U.S. Department of Energy[2]	43	28	45	21	24	19	14
Environmental Protection Agency	77	84	71	96	63	67	42
General Services Administration	27	13	11	13	8	1	0
U.S. Department of Housing and Urban Development	263	170	140	140	93	42	13
U.S. Department of the Interior	91	126	131	107	127	146	115
Interstate Commerce Commission	9	8	5	2	2	2	1
Nuclear Regulatory Commission	25	19	17	47	31	11	11
Regional River Basin Commissions	6	12	8	8	2	0	0
Tennessee Valley Authority	6	9	6	4	—	2	1
U.S. Department of Transportation	288	277	189	221	183	169	147
Other Federal agencies, commissions, councils	30	59	14	18	20	9	9
Total, all Federal agencies	1,355	1,273	966	1,033	808	677	577

Years refer to calendar years.
[1]Number of Environmental Impact Statements including draft EISs, EIS Supplements, and Final EISs filed during specific year. Some proposed projects may have several drafts and final EISs filed over a period of years.
[2]Includes predecessor agencies of the Department of Energy.

Source: U.S. Environmental Protection Agency, Office of Federal Activities, unpublished data.